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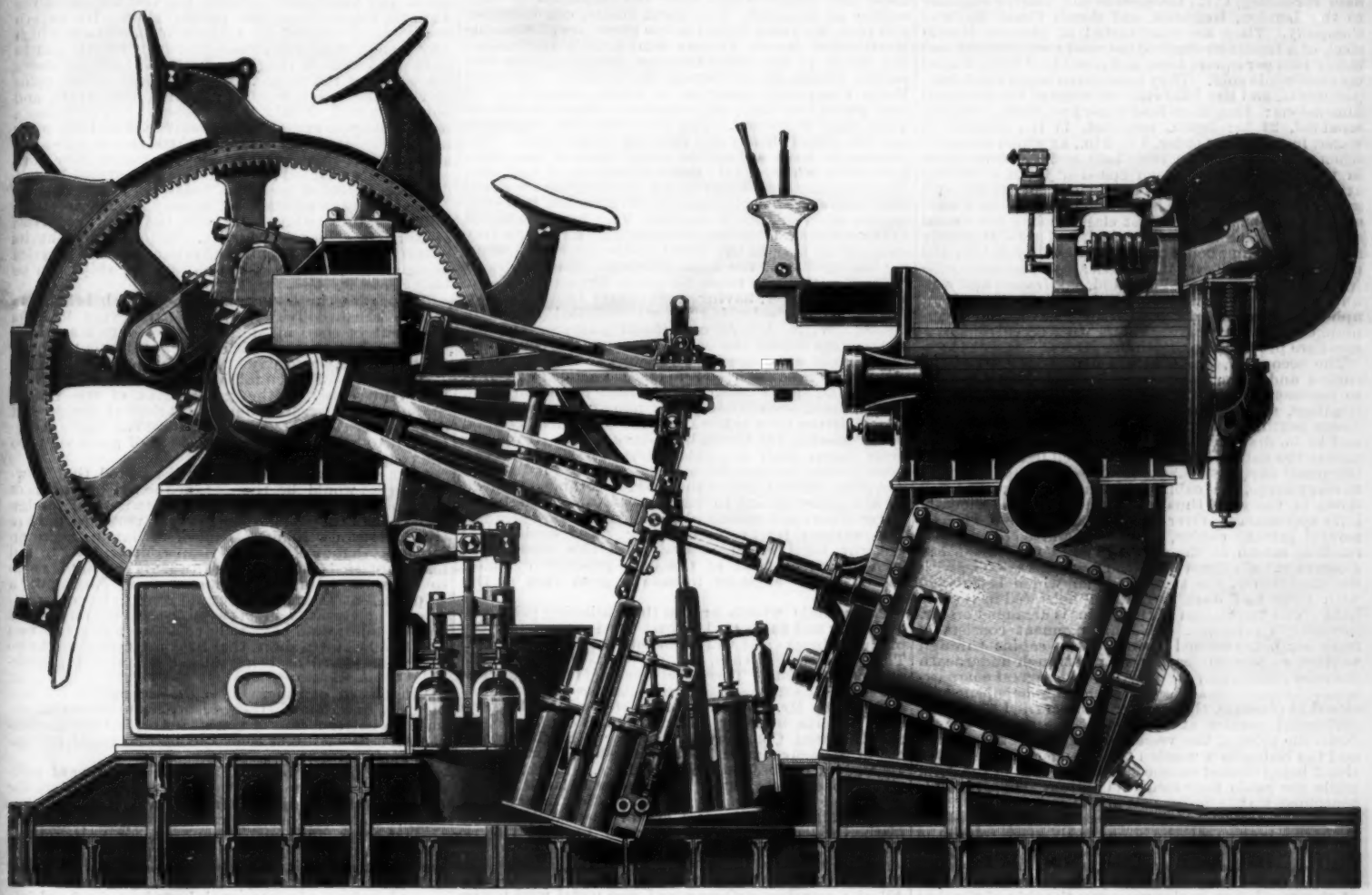
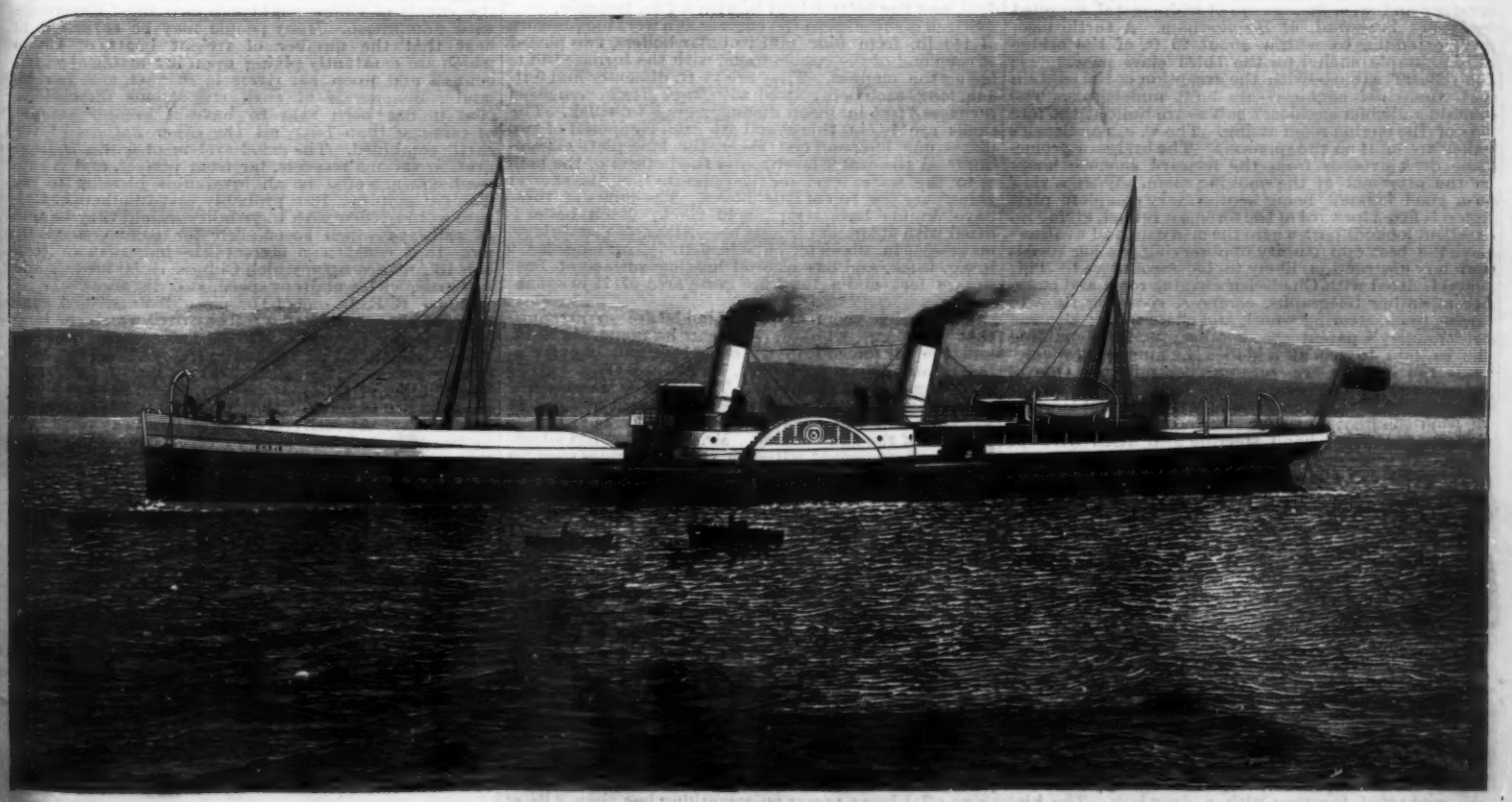


COMPOUND ENGINES OF THE CHANNEL STEAMER PARIS—LONDON AND BRIGHTON R.R. CO.



THE CHANNEL STEAMER PARIS

THE CHANNEL STEAMER PARIS.

WE illustrate one of the two sister boats which do so much to render the route from London to Paris *via* Newhaven and Dieppe so popular. We also illustrate their engines. As good and comfortable sea boats these vessels leave nothing to be desired, and visitors to the Paris exhibition this year will have no reason to regret the selection of this route in lieu of that by Calais. Captain Hemmings and Captain Jensen leave nothing undone to render their passengers comfortable.

These vessels were built in 1888, for the London, Brighton, and South Coast and the Western of France Railway companies, to run between Newhaven and Dieppe in connection with their express Continental service between London and Paris. They were built and engined by the Fairfield Shipbuilding and Engineering company, Govan, from the designs of Mr. William Stroudley, C.E., locomotive and marine engineer to the London, Brighton, and South Coast Railway Company. They are constructed of Siemens-Martin steel, of a tensile strength of between twenty-eight and thirty tons per square inch, and capable of being folded up close while cold. They have seven water tight compartments, and the following are some of the principal dimensions: Length on load water line, 250 ft.; breadth moulded, 29 ft.; depth, moulded, 15 ft.; draught of water, in sea going order, 8 ft. 2 in., at which draught, when on trial between the Cloch and Cumbrae lights in the river Clyde, a mean speed of 19·057 knots was attained. Accommodation is provided for 466 first, 108 second, and 133 third class passengers, making a total of 706 passengers. The first class saloons are placed abaft the engine and boiler space, and are elaborately fitted, everything being of the first quality finish; the paneling is of chestnut, artistically decorated with fruit and flowers painted by hand, oak frames and walnut and gold pilasters, cornices, capitals and beadings, upholstered with crimson Utrecht velvet and silver-plated fittings; revolving chairs with eccentric movement are provided at the dining tables.

The second class saloons are placed forward of the engine and boiler space, the woodwork being grained to represent maple panels, oak frames and teak wood beadings, and upholstered with figured velvet pile. Large portlights, Mullam's patent, 15 in. diameter aft and 10 in. diameter forward, have been used; by this means the cabins are thoroughly well lighted without the usual skylights. As these vessels are not intended to carry cargo, the cabin floors have been placed well down in the ship, thus giving them an exceptionally lofty appearance. Over the first class saloons are placed several private cabins, a lavatory, and a commodious smoking saloon at the after end; these are finished in a somewhat similar style to the first class saloons, with the exception of the smoking room, which is paneled with light and dark oak, and upholstered in Buffalo hide. The ventilation of the cabins is arranged on Mr. Stroudley's principle. This arrangement consists in fresh air being carried down to the cabins through ventilators communicating with a trough underneath the cabin floors, and escaping into the several compartments through brass grids, which can be opened or closed at pleasure, the foul air being carried through a perforated cornice at the top of the cabins, thence down the sides of the vessel between the skin plating and the lining to a wooden trunk under the seats, this trunk being formed on one side by the skin of the ship, while the cabin floor forms its bottom; this airway is continued up the bulkheads at the ends, the air being discharged from it into iron pipes which communicate with the bottom of the annular air space round the funnels, this air space being carried to within a foot of the top of them. This system has been found most effective. It not only thoroughly ventilates the interior of the vessel, but it also preserves the skin of the ship by the continual passage of the air. The cabins are heated with steam heating pipes and the vessel is lighted throughout with the electric light supplied and fitted by the Anglo-American Brush Company. The lavatory and w. c. fittings are of white metal, supplied by Messrs. Beresford, of Birmingham. A turtle back deck extending to within about 20 ft. of the bridge affords ample shelter for the third class passengers; the officers' cabins—with the exception of the captain and the chief engineer—are built under this. The captain and chief engineer's cabins are built at the fore side of the engine room casing. The w. c.'s and cook's galley are built on the sponsons. The bridge or promenade deck extends from the forward sponson house to the after end of the smoking room. With a view to a good lookout being kept, a very complete pilot house is fitted forward of the foremost funnel, giving an excellent lookout post, where the men can in all weathers have the best opportunity of observing passing vessels and any obstruction likely to be encountered. This house is fitted with Chadburn's engine room and steering repeating telegraphs, compass, speaking tube to engine room, steering wheel, and chart table; also one of Stroudley's patent speed indicators, thus enabling the captain to see at a glance the number of revolutions the engines are running per minute. One of Harrison's steam steering engines is fixed in the engine room on top of the high pressure cylinder, and is worked from the pilot house for steering the vessel. There is also a powerful hand steering gear fitted over the rudder, the connections to the rudder being effected by a clutch which slides on the rudder head, and so arranged that it takes in one gear before letting go the other. This is fitted with a suitable lever, so that the change can be made in a few seconds in any state of the weather. These vessels are fitted with four large lifeboats, having Sample Ward's disengaging gear, and four Shepherd's collapsible boats, the former lying in skids, and the latter lying inverted alongside them, thus utilizing the same davits.

These vessels are propelled by a pair of compound surface condensing engines of 3,400 indicated horse power, making a maximum of 52 and a minimum of 49 revolutions per minute. The cylinders are placed abaft the shafts, which are carried on the condenser, the high pressure cylinder being on top of the low pressure cylinder, which is diagonal. These cylinders are placed one slightly to port and the other to starboard of the center line of the vessel, so as to bring them into line with their respective crank pins, which are connected together with a drag link. The high and low pressure cylinders are respectively 46 in. and 89 in. in diameter, the stroke in both cases being 6 ft. They are steam jacketed, and provided with manholes in the covers for access to interior. The pistons are of cast steel, of dish form, adopted by Mr. Stroudley with great success in his locomotives and steam vessels. Each junk ring has a shoe cast on the lower part of its circumference, so as to increase its bearing area on the cylinder. This arrangement was designed by Mr. Stroudley to dispense with tail rods passing through the cylinder covers, and has proved to work most satisfactorily. The high pressure cylinder is fitted with a single ported slide valve, while the valve of the low pressure cylinder is double ported. The valves are driven by link motion, the expansion links being of the double bar type. The valve spindles, eccentric rod ends, and lifting links are fitted with adjustable bearings. Each valve motion is reversed separately by Brown's patent steam and hydraulic reversing engine, arranged with one oil and two steam cylinders, working direct on to the expansion links. By this arrangement the engineer can alter the expansion of each engine as required. The crank shafts, crank cheeks and pins, the latter forged in one piece, are of Siemens-Martin steel, Messrs. Vickers, Sons & Co.'s best make; the whole of the other forgings for the engines and paddle wheels are of Siemens-Martin steel—Parkhead Forge Company's make—of a tensile strength of 33 tons per square inch, and capable of being folded up quite close while cold. The shafts are 16 in. diameter, and the crank cheeks and pins are forged solid. The crossheads have adjustable guide faces of cast steel, lined with white metal; the condenser is of cast iron, with plummer blocks cast on for carrying the air pump shaft, and cast steel plummer blocks attached for carrying the main shafts. These have long brackets bolted to the comming of the engine room, and forming a very strong cross stay to the vessel, at the same time securing the rigidity of the main bearings. The condenser is fitted with brass tubes tinned on the outside, ¾ in. external diameter, having 3,681 square feet of cooling surface. The condensing water is supplied by one of Messrs. W. H. Allen's centrifugal pumping engines. This pump forces the water through the condenser, the tubes of which are in two groups, so that the water makes two runs from end to end. The air pump is of gun metal, single acting, 37 in. diameter, with 30 in. stroke, fitted with Thompson's patent metallic valve, and is driven by a bell crank lever connected by a rod to the crosshead of the high pressure engine. From the same pump shaft are also driven two feed and two bilge pumps, having gun metal plungers 8 in. diameter and 18 in. stroke; one of the latter is arranged to work as a sanitary pump, to circulate water through the water closets and urinals when the engines are at work. The various levers for handling these engines are brought together on a level with the main deck, immediately in front of the high pressure cylinder, enabling the engineer to have a good view of the engines.

The paddle wheels are on the feathering principle, overhung and supported by cast steel slings under the plummer blocks and wing brackets on the ship's side. They have inside rims, and are 17 ft. diameter to the axes of the floats. There are nine floats in each wheel curved on the driving face, with flanges at the ends as designed by Mr. Stroudley for the steamships Brighton and Victoria, built by Messrs. John Elder & Co. for the Brighton Company in the year 1878. The floats are of Siemens-Martin hard rolled steel, 10 ft. by 3 ft. 7½ in.; six of these in each wheel are ⅜ in. thick, two 1¼ in., one 1⅝ in. thick, to properly balance the engines and prevent fore and aft motion in the ship. The paddle wheel centers are of cast steel, also the feathering studs and feathering rod bosses. The recesses for the paddle arm are planed parallel as to their length, but are slightly tapered as to their depth, so that the arms are drawn in by the bolts to a metallic fit. All the wearing surfaces are of gun metal working on lignum vitæ. All this work is put together with turned and fitted bolts, having cup heads and one nut to each bolt, the point of the bolt being slightly riveted over. All bolt holes are opened out with a cylinder drill, and the bolts driven in with a 7 lb. hammer.

Steam is supplied to the engines at a working pressure of 110 lb. from four multitubular boilers, two placed at each end of the engine room, with the furnace fronts facing the engines. They are 13 ft. diameter and 9 ft. 6 in. long, each being fitted with three Fox's corrugated furnaces 3 ft. 5 in. mean diameter by ⅞ in. thick. The shells are 1 1/16 in. thick, and are each composed of two plates, one long and one short, the long plate extending from the water level round the bottom of the boiler to the water level on the opposite side, the shorter going over the top of the boiler. The joints of these have double butt straps ⅞ in. thick. Each boiler is fitted with 318 patent iron tubes—Allan, of Coatbridge, make—2¾ in. diameter outside, 6 ft. 7½ in. long, No. 9 b.w.g. thick, and has a total heating surface of 1,842 square feet and a total fire grate area of 71·75 square feet.

The engine room and stokeholds are so arranged that the doors, windows, etc., can be made air tight, and the air forced into the same by a pair of 6 ft. diameter fans driven by one W. H. Allen & Co.'s 7 in. by 7 in. single cylinder engine. This engine is attached to the high pressure steam chest to prevent noise when working, and the exhaust steam is delivered into the receiver of the main engine. Mr. Stroudley has adopted this arrangement with the various engines used for electric lighting, circulating pumps, fans, etc., for some years, the back pressure entirely preventing the usual disagreeable knocking caused by these small engines, particularly when the exhaust is turned directly into the condenser. The average horse power used in making the ordinary runs does not exceed 3,000. The maximum speed at which these vessels have worked on the passage between Newhaven and Dieppe gives an average from pierhead to pierhead of 19¼ knots per hour, the time being three hours twenty minutes; the average time for the month was three hours thirty-two minutes. These boats were designed for the purpose of making the passage from wharf to wharf in four hours, and as the time required to get from the wharf to pierhead and pierhead to wharf on the other side only amounts to about twelve minutes, they have a considerable margin of power to keep the official time and meet the emergencies of bad weather. A careful analysis of the coal burned shows that these engines give off 1 horse power on something less than 2 lb. of the average duty. This of course includes steam used in the fan engine, steering engine, heating all cabins, etc., steam winch engine, and engine used for circulating condenser water. Were these engines only credited with the coal actually burnt, the consumption per horse power would be about 1¾ lb. only.—*The Engineer.*

EADS' SHIP RAILWAY.*

By JOHN C. HENDERSON.

CONTERMINOUS for fourteen hundred or more miles with the southern border of the republic of the United States lies the republic of Mexico. Mexico has an area about sixteen times that of the great State of New York.

South of Mexico for about 1,200 miles extends a wondrously beautiful and fertile land, whose width varies from about 300 to about 28 miles. This picturesque land may be viewed as a great causeway which, while uniting North and South America, divides in the middle of the American continent the vast waters of the Atlantic Ocean from the Pacific main. Its superb scenery is diversified by a chain of mountains which may almost be said to extend its entire length, and to have peaks which rise from 3,000 to 14,000 feet above the waters of the oceans. From a geographical point of view the great isthmus which unites North and South America should be considered as embracing a part of Mexico, and as being about 1,400 or 1,500 miles in length. Its area is about 300,000 square miles—an area out of which six States of the size of New York could be carved. This isthmus is a natural bridge, destined to be of priceless value to the people of America—over which a great railway is some time to be built, a railway which will unite the railway systems of North and South America. Happily, without its character as a bridge uniting North and South America being altered, interoceanic highways for ships can be built across it.

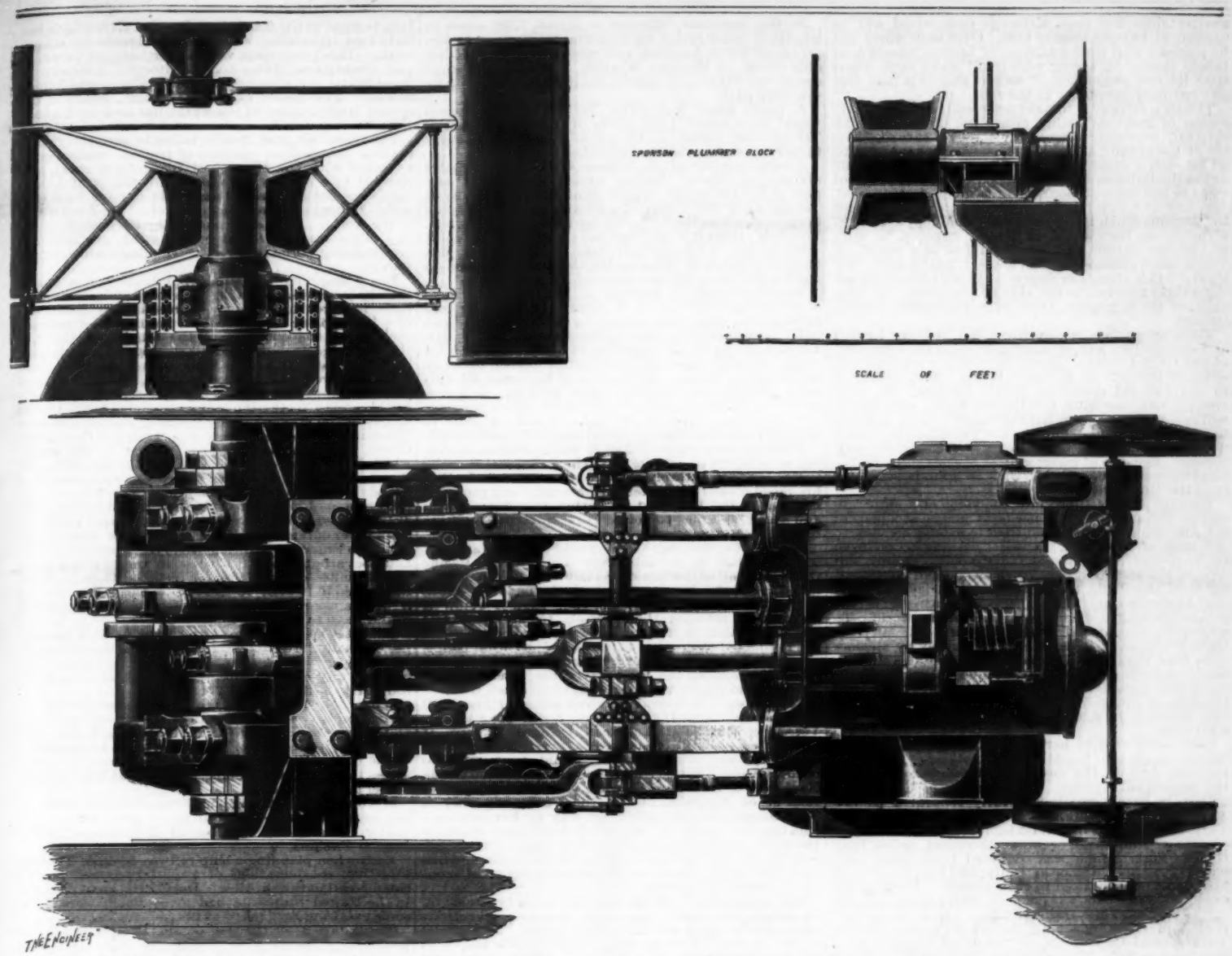
The part of the American isthmus which belongs to Mexico is called Tehuantepec. In the year 1847 the President of the United States offered to make with Mexico a treaty by which the government of the United States would pay fifteen millions of dollars for Tehuantepec. Fifteen millions of dollars in the year 1847 represented to the government of the United States a vastly greater sum than it does at the present day. American statesmanship, however, justly recognized it to be a geographical position of great value to the people of North America.

After expensive surveys it was discovered that, however great would be the distance saved by vessels of the United States engaged in coastwise and foreign trade, could they be borne across the northern part of the American isthmus instead of having to make an immense detour of the American continent, or to sail many hundreds of miles southwardly to enable them to cross the isthmus at Panama or at Nicaragua, a ship canal at Tehuantepec would have to be constructed over an elevation of between 700 and 800 feet above the sea, and would have to have between one and two hundred locks—in short, that its construction might be justly considered as being almost or quite impracticable. But Captain James B. Eads—one of the most distinguished of American engineers—raised the momentous question whether science is not equal to devising a better means of transit for ocean vessels across the American isthmus than the best of canal navigation could afford?

One peculiarity, believed by quite a number of travelers to characterize some Oriental nations, is that the people for generation after generation use only the same mechanical contrivances that were employed by their fathers. For many hundreds of years canals have been used as highways for commerce in different parts of the world. The building of canals was, for certain purposes, an improvement upon roads. For many hundreds of years canals have been used as highways for commerce in different parts of the world. The famous canals of China have done much to bind together many of its widely separated sections of country. Long before America was discovered by Columbus, the canals of China might well have filled Europeans with admiration. Many people may be surprised to hear that the number of freight boats of China which are constantly plying upon her artificial watercourses and upon her rivers is so vast, and her inland commerce is of such stupendous dimensions, that it has been said to have a greater amount of tonnage than have all the other nations of the earth combined. The canal system of China is, however, in various respects, far from perfect, and a railroad system would be an invaluable blessing to the Chinese empire. But probably vast numbers of Chinese would listen with incredulity should they be told of railways which accomplish for commerce vastly more than canals can accomplish—indeed, of railroad cars in America upon which Chinese canal boats could be borne, with wondrous speed, vast distances.

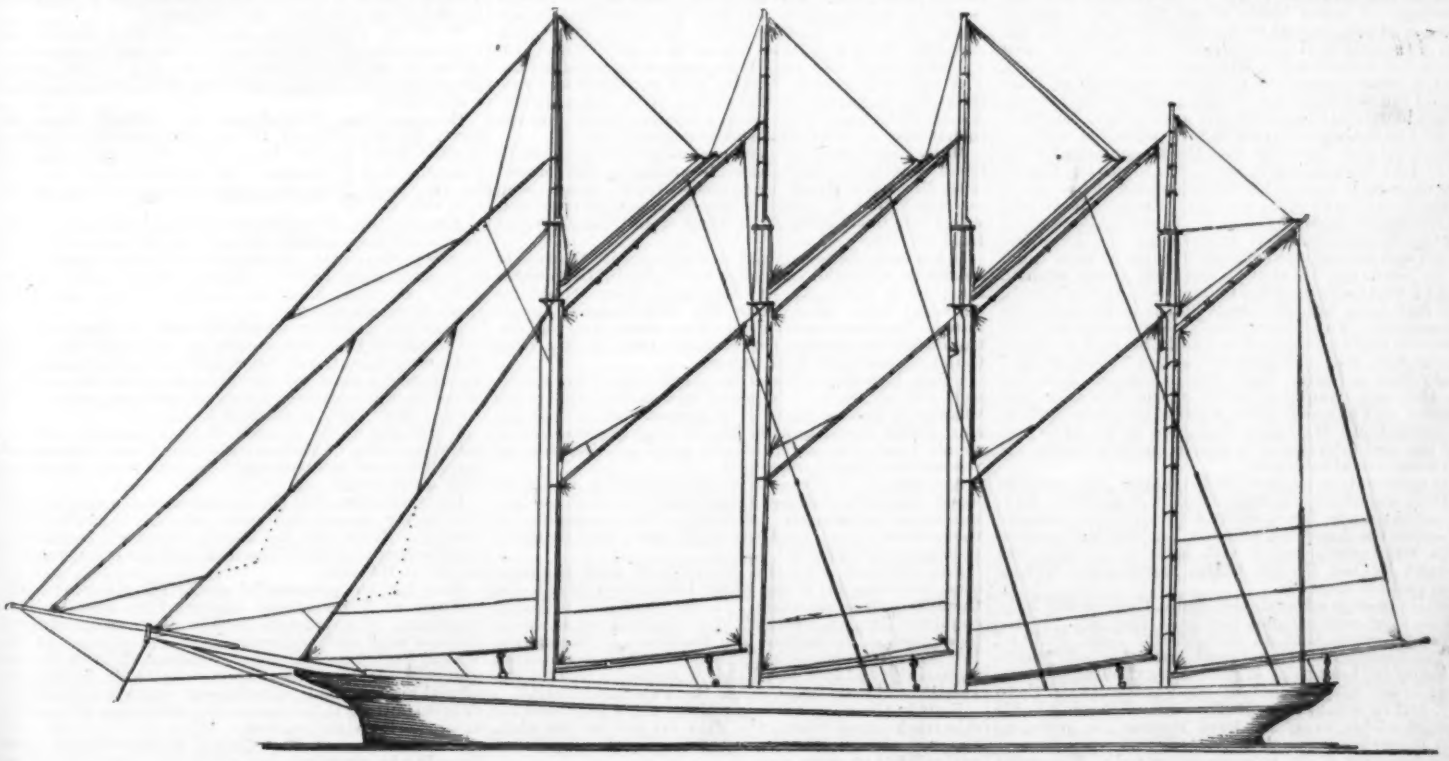
James B. Eads, one of the most distinguished engineers of his age, devised a railway over which the largest ships in the world are to be transported over the American isthmus of Tehuantepec. The railway is to have what may be called heavy rails of fine steel. The number of rails may be four, or six, or even eight, according to the size of the ship to be transported over the railway. At each end of the ship railway vessels are to be conducted into a basin especially prepared for them. This basin will open into what may be called a dry dock, such as is used in raising out of the water the largest ships in the world. As a vessel is raised out of the water it finds itself on a great car which was waiting at the bottom of the dry dock to receive it—a great car on wheels and on a railroad. By mechanical contrivances, based on very interesting scientific principles, the ship is laid in its cradle as gently, one may almost be permitted to say, as a mother lays her babe upon its little bed. The railway car is to have a large number—some hundreds—of wheels, and is to be so admirably constructed of steel that it will possess very great strength. The ship when on the car is, by what may well be called a masterpiece of engineering ingenuity, to rest on supports which will so adjust themselves to it that the vessel will be practically as truly water borne as though it rested on a lake. In a wonderfully ingenious manner the weight of the vessel is to be equalized and distributed over the entire car. The car, which is to be several hundred feet in

* Extract from a paper read before the Academy of Sciences by John C. Henderson, Monday evening, April 22, 1889.



COMPOUND ENGINES OF THE CHANNEL STEAMER PARIS—LONDON AND BRIGHTON R.R. CO.

length, can be lengthened or shortened according to the size of the vessel which it is to transport. The car wheels are to be two feet in diameter, and are to be placed three feet apart on the six or more rails on which the ship car is to run. The question may be raised. "Would not a loaded ship—which would weigh far more heavily in its center than at its bow or stern—when placed on a car, be of such stupendous weight that the ground would give way under the crushing pressure which the rails would be called upon to bear?" Eads, when dealing with such a question, showed that a vessel upon the ship car would have its weight, by the agency of its cradle and the construction of the car, so equalized and distributed over a large surface that no one of the wheels of the car will have to bear a weight


Note.
Bonnets drop off of lower stay sails,
Middle stay sails stow down to leeward of the lower stay sails in to the mast.
The mizen brails.
Scale 1/16 in = 1 foot
Length between perpendiculars 142'
" over all 167'
Lower masts 100'
Top " 46'

ADMIRAL R. B. FORBES' NEW RIG FOR MANY-MASTED VESSELS.

greater than five tons, although each wheel will be capable of bearing twenty tons. Over each wheel will be placed a steel spring capable of bearing twenty tons before closing—a spring which will make each wheel bear its fair proportion of weight should it pass over any ordinary inequality in the rails.

The ship railway is to have practically no curves. By means of great deflecting tables the direction of the ship car, whenever necessary, is to be turned. The lay of the ground at Tehuantepec is very happily suited for such a great railroad. The ship can be borne across the Isthmus of Tehuantepec at the rate of about eight or ten miles an hour, or at a much faster speed. Ships using a ship railway would not only travel across the isthmus much faster than they could by means of a canal, but they would, in various respects, be safer on the railroad car than they would be in a canal. A vessel, when passing through a canal, has to move very slowly. It is always in danger of being injured by going a little too close to the side of the canal. It may even, at times, ground under very unpleasant circumstances.

There are various reasons why a ship railway, located at Tehuantepec, will be of great value to the commerce of the United States. It will be within a few hundred miles of the city of Mexico. It can easily be united to the railroad system of North America. Its commercial relations with the United States and Mexico will necessarily be peculiarly intimate. Eads planned to make a very fine harbor for Tehuantepec, which would become an entrepot for a vast commerce with Mexico. Because of geographical reasons ships at Tehuantepec could be supplied with an abundance of coal from the United States.

To even faintly appreciate the value of a ship railway at Tehuantepec, one needs to glance at a map of the American continent and then to extend his view to the map of the world. A vessel wishing to go from the harbor of New York to San Francisco cannot sail around the northern part of the American continent, for then she would have to go into the icy regions of the Arctic Ocean. The American continent is the greatest in length of any continent in the world. To go around its cold and stormy southern extremity—or Cape Horn, as it is called—on a journey by steamer from New York to San Francisco, necessitates the sailing by steamer of 14,200 nautical miles—a nautical mile being about one-sixth greater in length than is a statute mile. A ship railway at Tehuantepec would shorten this distance by 9,800 miles, making the voyage but 4,400 miles.

One could wish to here pause to consider how inestimably important to nations is commerce; how it affects the comfort, the wealth, the intellectual tone and the manners of a people. It is a means of binding together, in happy relations, widely separated people. Many an humble workman, living in the city of New York, has upon his breakfast table tea which has been transported nineteen or more thousand miles from China; sugar which was obtained from sugar cane which grew in Cuba or in India; and fruits that were raised in climates suited to their growth. Perhaps the bread which he eats was made of wheat raised on the western coast of the United States and has been transported in ships by a long, dangerous voyage to New York around Cape Horn, or "Cape of Storms," as it has been called. The people of China carried on, for hundreds of years, an immense internal trade before their ports were thrown open to the commerce of the world. They had not the knowledge of European arts and inventions that an extensive foreign commerce would have given them. The steam engine, the locomotive, and many great inventions have scarcely yet been introduced into their "Flowery Kingdom."

Far less refined than they are would be, to-day, the people of England were it not for the wealth and the advantages of many kinds which they have reaped by means of commercial transactions with foreign nations. One may well be surprised to be told that even forks, a few centuries ago, were unknown in England. When a time came that the polished people of Italy adopted the useful fashion of using forks at their meals, English merchants imported the novelty into England. It is said that Queen Elizabeth was presented with an ornamented fork, but that that Queen continued to do as she had been brought up to do, to use her fingers when eating her meat—doubtless keeping at her side a napkin on which to often wipe her hands. It is said that she looked upon forks as worthless and regarded their use as foppish. But to-day even the humblest Englishman has adopted the use of forks at meal times as a matter so natural that he does not pause even to think of what a refinement in manners at the dining table has been brought about by the instrumentality of commerce. The Chinese to-day—save some of their merchants and travelers—can hardly be said to know of forks, and still use what are called "chop sticks." To say that a people have little commerce is to say that they are devoid of many of the decencies and comforts and of some of the greatest blessings of modern civilization. Well may statesmen endeavor to promote the best interests of a people by duly caring for their commercial interests.

The government of the United States has spent in one form and another a large amount of money in having surveys made for a suitable place for a passageway across the American isthmus. A practicable route for an interoceanic canal with locks at Panama was surveyed by the United States government during Grant's administration.

Had De Lesseps adopted that route, there would have been an interoceanic canal to-day at Panama. It was found by surveys that an interoceanic canal could be built at Nicaragua. Gen. Grant refused an offer made to him by De Lesseps of fifty or sixty thousand dollars a year to act as president of the Panama Canal Company, but he would have gladly—indeed it was a noble ambition of his to do so—have become the president of an interoceanic canal at Nicaragua.

The building of an interoceanic canal at Nicaragua has much in some respects to commend it to American citizens, but grave doubts were entertained by Capt. Eads, who was one of the highest of authorities on such a subject, whether it would be practicable to make a suitable harbor on the eastern terminus of the canal. In Capt. Eads' opinion a ship railway at Tehuantepec would be vastly better for the people of the United States, owing to very important political as well as commercial reasons, than would be even an American interoceanic canal at Nicaragua.

As the American isthmus is about 1,500 miles in length, it must make an important difference to the people of North America, and indeed to no inconsiderable degree to England, whether a gateway for ships across the isthmus is opened on its northern or on its southern part.

A vessel going from New York to San Francisco would save about 1,173 miles by going by way of Tehuantepec instead of by way of Panama. On every round trip it would save 2,346 miles.

A large number of the vessels of the United States are sailing vessels. Sailing vessels going from any port of the United States and using the ship railway at Tehuantepec would enjoy the great advantage of being borne onward on their journey by friendly trade winds. To a less extent it would also have this advantage if it went by way of the splendid lake of Nicaragua. But there is a region of calms on the Caribbean Sea and on the Pacific Ocean off the coasts of Panama.

Vessels crossing the isthmus at Panama would have to go through this region of calms. The mariner who attempts to cross this region in a sailing vessel is, as a rule, subjected to a heart-sickening detention. His vessel is apt to lie for day after day and for week after week, and sometimes for month after month, listlessly on the glassy waters. If the sails of his vessel fill with wind, and his heart begins to beat with joy, he is very apt, if not indeed certain, to find that only a momentary breeze has swept by, or that a squall, ushering in a tropical shower, threatens his vessel with destruction.

When the sun shines it does so with a heat so scorching as to injure in various ways the vessel and to make the sailors prematurely old. As the sailor finds that his vessel makes day after day scarcely any progress, he is apt to feel he would far rather face fierce storms and sail 10,000 miles to round Cape Horn than to have his life wasted in a region of calms.

But few if any sailing vessels would probably attempt a second time to go from New York to the Pacific Ocean by way of Panama. Skillful navigators might indeed be enabled to get through the region of calms in but one or two weeks longer time than it would on an average take for their vessels to go by way of Nicaragua, that is if they knew just how to keep on the borders of the region of calms or just what course to at times take, but on every round trip a sailing vessel, under almost the most favorable circumstances that it could expect to have, would lose much time.

Tehuantepec is several hundred miles farther north of Nicaragua than is Nicaragua north of Panama. Vessels crossing the American isthmus by way of Tehuantepec would often have a breeze when vessels going by way of Nicaragua would meet with no friendly wind. If two sailing vessels should start from New York or from New Orleans, for almost any part of Asia or of Australia, one of them going by way of Tehuantepec and the other by way of Panama, as a rule the one going by way of Tehuantepec would be thousands of miles on its journey, perhaps at the Sandwich Islands, if its course lay in their direction, while the other sailing vessel would be in the region of calms off the coasts of Panama.

While a wooden sailing vessel is lying becalmed off the coast of Panama, it is being attacked beneath its water line by what are called ship worms. The species of ship worm known as the *Teredo navalis* is now to be found probably in every sea. These worms did such injury to the piles which were used on the great dikes which protect Holland from the sea, dikes which have cost not less than $1,500,000, that the Dutch government at times appealed to science to deliver them from their attacks.

The *Teredo navalis*, or the so-called ship worms, attack when very young wooden vessels that are not covered with copper sheathing, or in some way protected from them. The holes by which they enter the sides of a vessel may be no larger than pins' heads, but when they have once entered the wood they grow rapidly. They line their homes in a ship's sides with a kind of shell. As they bore away they grow in size. The ordinary *Teredo navalis* does not grow as a rule to be very large, but in the waters off the coasts of the American isthmus ship worms become sometimes ten inches or even twice that size in length.

Many a gallant ship has been obliged to succumb to these creatures, their hulls becoming honeycombed with the holes which they have bored. It has been supposed that if vessels could go suddenly from salt water into fresh water that they would be delivered from this foe.

It has been believed, and perhaps justly, that could vessels be at anchor in a large and splendid fresh water lake, as is the Lake of Nicaragua, they would be delivered from these pests, but this dreaded *Teredo navalis* has been found in brackish water, and one distinguished naturalist has claimed that it has been found alive even in fresh water.

Could, however, a vessel be taken out of the water, as it will be when it is being transported across the isthmus of Tehuantepec, it is almost certain that the ship worms would quickly die, as they are so sensitive to air that they never attack piers or the sides of vessels above their water line.

Another foe to ships—to vessels of iron as well as of wood—is a little shell fish or mollusk which is commonly known as the barnacle. Mollusks of this species fasten themselves in such numbers on a vessel that its speed becomes much affected.

Fast steamers, even the finest which float the seas, must be taken out of the water twice every year to rid them from these shell fish. The barnacle, it is believed, could not live if a vessel could enter fresh water, could lie at anchor, for example, in the Lake of Nicaragua. But though the barnacle would die, its shell would often be so cemented to a vessel that it would be well for the vessel could it be taken out of the water and scraped.

Eads in planning his ship railway made provision for side tracks upon which the ship car can be run while the ship with which it is loaded is scraped and painted and refitted in every way.

Tehuantepec is some 600 or 700 or more miles nearer to the United States by land than is Nicaragua. By looking at a map of the American continent it can be seen that while Panama and Nicaragua are bathed by the waters of the Caribbean Sea, Tehuantepec is washed by the waters of the almost land-inclosed Gulf of Mexico. This great American gulf is about 1,000 miles in length by 800 miles in width.

Into this great basin of water flows a vaster river system than is found on any continent save America. Into it empties the Mississippi River, a river which has forty-two tributaries which are navigable by steamboats. This great river with its tributaries waters in part twenty-one States and Territori . Fourteen of these States are sometimes called "Mississippi Valley States." The valley of the Mississippi, which is the second largest valley of the world, has an area of about 1,244,000 square miles.

This vast, fair, and fertile valley is capable of supporting hundreds of millions of people. Joined or to be joined with the Mississippi River by a canal, and possibly by a railway for vessels, are the great American lakes—lakes or inland seas—which have been estimated to contain about one-third of all the fresh water in the world. As in some part of the Mississippi valley any clime can be found, very varied products are always being borne in a very economical manner on its waters.

For a long time the Mississippi River was a closed river to large vessels, owing to a bar at its entrance. Eads rendered his country an inestimably great service by devising a method of making a permanent channel at the entrance of the Mississippi River, a channel large enough to admit the biggest vessels used in commerce. Although Eads in various ways had rendered services of very great value, one might say of priceless value, to his country, yet he aspired by practically opening to the immense commerce borne on the waters of the Mississippi, by means of a ship railway at Tehuantepec, a channel into the waters of the Pacific Ocean, an ocean which is the vastest in the world, which has an area of about two-fifths of the surface of the world, and waters the shores of continents and islands where live 600 or 700 millions of people.

By a map of the Gulf of Mexico it will be seen that Tehuantepec is opposite to the point where the Mississippi River enters the gulf. A steam vessel when it sails from San Francisco to the mouth of the Mississippi River and goes around Cape Horn has to travel about 16,112 statute miles, a much greater distance than it would have to go if it went to Asia or to Australia. Should it be transported across the isthmus at Panama, it would have to sail 5,418 miles.

Should it be borne across the isthmus at Tehuantepec, it would have to travel only 3,561 miles, a less distance by 1,857 miles than by way of Panama. If it went by way of Tehuantepec, it would save on every round trip a distance of 3,714 miles.

When one reflects how large a commerce might be carried on between the mouth of the Mississippi River and the western coast of the United States, he may well feel that it is a matter of vast importance to the people of the United States that the place of transit for ships across the American isthmus should be at Tehuantepec rather than at Panama.

It would be worth many millions of dollars yearly to the great coastwise trade of the United States to be enabled to cross the isthmus at Tehuantepec rather than at Panama.

Eads when planning a ship railway to cross Tehuantepec had considerations of a military as well as of a commercial nature in view. During the great civil war in the United States he had given much thought to some great military needs of his country.

Three days after the flag of the United States had been fired upon at Fort Sumter, he had been summoned by a member of Lincoln's cabinet to Washington to advise his government respecting the wisest manner of utilizing for military purposes the Mississippi and other rivers.

The great engineer at once himself built with wonderful dispatch eight river gunboats. Shortly after presenting these formidable vessels to his government he had six more gunboats built, four of them being in part constructed on plans which he himself devised. The services of a military nature which he was enabled to render his country were very great.

With his trained eye Eads saw that should the United States become engaged in war with a European power, it might endeavor to do the United States great injury by seizing and using to its own advantage a ship canal.

He feared that it would be very difficult, to say the least, for the United States government to protect against great hostile fleets an interoceanic canal at Panama or at Nicaragua. An interoceanic canal could be very easily rendered useless for quite long periods in a time of war.

A single torpedo would be enough to destroy a lock and to let loose a flood of water which might do much injury to the canal. A single vessel intentionally sunk in a canal might make it impassable for a fleet of war ships. Damage done to a ship railway could be quickly repaired.

Eads had plans by which the Gulf of Mexico would be practically converted into an American lake. By defending its entrance he would defend Tehuantepec. He devised a plan for the defense of the ship railway which would practically make it secure against attack by any fleet likely to attempt its capture.

It was also to be in such close connection with the railway system of Mexico and of the United States that large bodies of soldiers could be sent to its defense at very short notice.

On the eastern side the approach to the ship railway is to be for twenty-five miles by the beautiful Coatzacoalcos River. On the Pacific side it will be through a quite large lagoon. The length of the railway was to be about 134 miles.

Eads had the pleasure of seeing his plans for a ship railway at Tehuantepec approved by very eminent engineers. Constructors-in-chief of the navy of Great Britain and constructors-in-chief of the navy of the United States, as well as very eminent builders of ships and of dry docks of Great Britain, united in giving in an official manner their indorsement to the practicability of transporting ships across the American isthmus by means of Eads' ship railway.

A committee of the United States Senate, after listening to whatever objections the advocates of an interoceanic canal had to offer to Eads' plans for a ship railway, on March 6, 1882, made a report, in the course of which it said: "The first question the committee considered was as to the practicability of constructing a railway for the purpose of transporting ships and their cargoes. The testimony before the committee conclusively demonstrates the fact that such a railway is entirely practicable, and that loaded vessels can be transported over the same with absolute safety and economy."

In the course of its report the committee, after quoting from testimony given by American engineers respecting the practicability of constructing a ship railway, continues: "The testimony upon this subject is so overwhelming and conclusive in its character that the committee has no hesitation in reporting that the construction of a ship railway and its successful operation are entirely practicable."

The Senate committee, after quoting at considerable length from a very interesting report that a congressional committee had already made on the ship railway, a report which especially pointed out the immense advantages which the people of the United States would derive should the gateway for vessels crossing the American isthmus be at Tehuantepec rather than at Nicaragua or Panama, added the following statement: "The committee has considered the testimony taken before the House committee, and fully indorses the statement that Tehuantepec is the American route, and that the transit way should by all means be located there in preference to any other point upon the isthmus."

In connection with the Senate report just quoted, it is interesting to observe that President Cleveland in his annual message dated December 8, 1885, alluding to Eads' ship railway, somewhat incidentally said: "The Tehuantepec route is declared, by engineers of the highest repute and by competent scientists, to afford an entirely practicable transit for vessels and cargoes, by means of a ship railway from the Atlantic to the Pacific."

Such a statement, similar to what had been made by committees of Congress, must have been very gratifying to Eads.

In the light of the testimony which has been adduced in favor of the practicability of transporting ships across the American isthmus by means of a ship railway, we think it is not only a practicable but a grand project.

Eads wished the United States government, as well as the government of Mexico, to aid in the construction of the ship railway by guaranteeing a limited amount of interest on the money spent in building the railway. This money, however, was to be but practically a loan. The government of the United States was to receive in various ways very valuable concessions from the railway company.

One very interesting and important feature of Eads' project was that the United States government was not to pay any money in aiding the ship railway company unless it should successfully carry out its contract to transport over the railway in a specified manner vessels of a given tonnage. Unless the ship railway accomplished all that it agreed to do, it was to receive no aid in money from the government of the United States.

It was not given to Eads to live to see his proposed ship railway in active operation. Some of us, let us hope, will live to have that pleasure. Eads' ship railway is designed to transport in a day a far larger number of vessels than can an interoceanic canal.

It can be built much more rapidly than can a ship canal. It can afford, it is believed, to transport vessels at less cost than can be done by canal navigation. If successful, it will be a means of greatly increasing the inducements to Americans to build ships, and will in various ways call into life many new industries.

The people of the United States would not wish to see it controlled entirely by a foreign power. They would not wish to see it becoming a great monopoly, charging exorbitantly for transporting American vessels from ocean to ocean.

In perhaps no juster or better way could the government of the United States have a voice in its management than by duly aiding its construction. It may be worth every year to the people of the United States far more than will be its entire cost, even though that cost should be $50,000,000 or $100,000,000.

It will pass over a country having, except near the Coatzacoalcos River, a very health-giving climate. At either end of the ship railway a great commercial city may be expected to arise.

The government of Mexico is deeply interested in securing the construction of Eads' ship railway at Tehuantepec.

SUBMARINE EXCAVATIONS IN SAND.

EXCAVATIONS are now being made in Dutch waters for the recovery of the treasure carried by the ship of war Lutine, which, in 1799, founded upon a sand bank, and soon sunk, carrying down with her a large amount of gold and silver coin and bullion.

An endeavor has several times been made to recover this treasure, the value of which is estimated at about $6,000,000. The first excavations, made in 1800 and 1801, permitted of the recovery of gold and silver to the amount of nearly $280,000 in coin and bullion. The search was then suspended, and was resumed again in 1857 and continued up to 1860. As a result somewhat more than $220,000 were recovered. Again abandoned, the search was not resumed until 1886, and, although the results obtained up to 1887 represent but the small sum of $4,340, the new method of research proposed on this occasion by the Dutch engineer, W. H. Ter Meulen, and recently put in practice, is, it seems, giving so rapid results that there is reason to hope that the entire recovery of the buried treasure will soon be accomplished.

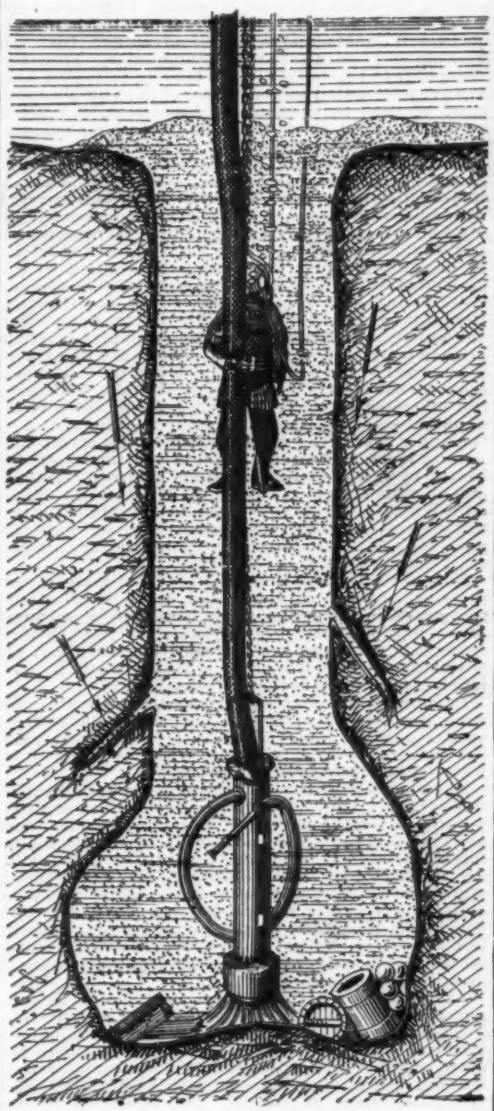
The system adopted by this Dutch engineer has some analogy with the one devised by Mr. Vetillart, government engineer, for submerging large blocks of artificial stone in the construction of ports. The system adopted at the port of Calais consists in forming in the blocks to be submerged an octagonal aperture designed for the reception of four small pipes, through which powerful streams of water are sent into the sand lying beneath the block. The sand is soon disintegrated, and is then extracted by a suction pump. In this way the huge block of artificial stone descends of itself, through its own weight, to the desired depth.

As will be seen from the description that follows, the system adopted by Mr. Ter Meulen is likewise based upon the injection of water into sand in order to disintegrate it, but the application made of it is quite peculiar, and, from this standpoint, offers a genuine interest.

The first excavations made, while giving the encouraging results that we have mentioned, had the inconvenience of disturbing the *debris* of the sunken ship, and of thus naturally rendering the subsequent researches more difficult. In 1800 and 1801 the work was carried on by sounding, with the aid of hooks and tongs, no divers up to then being employed. It was only starting from 1886 that recourse was had to the latter, who were let down into the holes formed by suction. But, on the one hand, the huge pile of sand that had to be crossed made it difficult for the diver to form a passage for himself to the bottom of the pit, and, on the other, the form and position of the hillocks were constantly varying through the effect of suction. It was then that Mr. Ter Meulen devised an apparatus that permits the diver to walk without danger in sandy soil down to a very great depth.

This apparatus, which we shall call a sand extractor, consists of a very strong hose seven inches in diameter, from the lower extremity of which is suspended a heavy cast iron tube five feet in length, with a copper rose, through which the water, injected into the hose with a strong pressure, radiates against the bed of sand.

The weight of the metallic part should not be less than five hundred pounds, so that the hose through which it is connected with the vessel that carries it may rapidly tauten at the moment that it is unrolled, and preserve a vertical position, even though there should be a current above the well to be sunk. In fact,



SAND EXTRACTOR.

if we suppose the weight of the mixture of sand and water to be four pounds per quart, and that of the pure water in the hose to be two pounds, the sand extractor would lose, for a length of three and three-quarter feet and a diameter of seven inches, forty-four pounds of its weight. Now, if the stratum of sand to be traversed were twenty-six feet, the total loss would amount to three hundred and fifty pounds.

The apparatus is mounted on board of a steamer having a forty horse power engine and a steam pump capable of furnishing at least five hundred gallons of water per minute up to a pressure of one hundred and twenty-five pounds to the square inch. So high a pressure is doubtless not indispensable, even though a twenty-six foot stratum of sand were to be traversed. Yet, as a means of precaution, it is well to have the pump capable of furnishing this work when need be.

The quantity of five hundred gallons per minute is considered as a minimum. The more water the steam pump can furnish, the better will be the result secured. For calculating the pressure required, it is necessary to take into account the fact that the density of the sand, reduced to the state of ooze, remains always less than two, that of the water being one. In a well twenty-six feet in depth, the pressure, therefore, does not reach that of fifty feet of pure water. If we deduct therefrom the weight of the water proper in the hose, we find that the injection has not even to overcome twenty-five feet of counter pressure of water. If we add the loss through friction in the hose, and an excess of pressure for strongly syringing the bottom of the well, we may admit that a pressure of one hundred and twenty-five pounds to the square inch amply supplies and answers every need.

The effect produced is easily explained. As soon as the extractor touches bottom, the sand is disintegrated and converted into ooze. A well is then formed which becomes deeper in measure as the apparatus is lowered. The slower the operation, the wider the well becomes. However, a narrow well is considered to offer more security against caving. Moreover, it would be scarcely worth while to make the well too wide, seeing that it would rapidly contract up to the limit corresponding to the mass of water injected; but such limit then remains invariable and as long as the influx of water continues. The caving in of the well during the operation of the pump is a thing materially impossible. Admitting that the extractor descends but 10 inches per minute (and this is a fair average), it is possible to reach the hulk of the Lutine in 9 minutes. The useful work of the diver may, therefore, begin within a very short time, and, in favorable weather, it may be carried on for several hours.

The apparatus having reached the bottom, and the diver having revolved it several times, the lower part of the well widens so as to form an excavation of from 10 to 12 feet in diameter. Although the diver works in entire darkness in this chamber, he is not subjected to deception. Not only can he touch the bottom, but he can sound it by means of a second and narrower hose connected with the other. Provided with this, he can inject water into the interstices of the vessel's remains, and open a passage therein, and is enabled to recognize the smallest coin by touch, down to the bed of clay upon which the Lutine lies. If he judges it expedient to destroy certain pieces of the hulk in order to facilitate his researches, he can do so by the aid of small charges of dynamite.

The figure represents the extractor at the moment when the well has just been finished. The excavation is still small, but it rapidly increases, and will soon become larger yet through the disintegration of the upper walls of the vault. Experience has demonstrated that the blocks of sand that may detach themselves from these walls are immediately disintegrated and converted into moving, liquid sand.

The pressure of the water forced into the well by the steam pump contributes greatly to the well's stability. As the latter is situated at the bottom of the sea in a bed of sand, and filled with oozy water, the injected water must have considerable force to enter it. It is therefore natural that artificial pressure thus produced should sustain the sides of the well. Only a partial caving can occur, and every block of agglomerated sand carried along by the torrent thickens the latter, increases the pressure in the well, and prevents the caving from extending.

As for the safety of the diver, the fear might be expressed that the injected water might take another issue, fill up the well, and imprison him. But such an accident could not occur unless the well had a depth exaggerated proportionally to the quantity of water injected.

On this condition evidently depends the security of the well, concurrently with the nature of the earth in which the excavating is done, that is to say, according as it is more or less permeable and loses through infiltration a greater or less quantity of the water designed to expel the sand. As for this latter condition, it is easy to see to that at the beginning of the excavation and takes measures in consequence.

So, too, the presence of strata of clay may become dangerous, as they are capable of leading to a change in direction of the ascending water. For greater security the lower extremity of the hose that enters the sand should not be absolutely impermeable, but it would be preferable to make it of strong sail cloth, and to surround it with an envelope of braided cord. Such a hose, as soon as submitted to pressure, will allow the water to filter and will form around itself a liquid envelope that will serve as a guide to the rising water.

The diver here differs from the ordinary diver in that the amount of lead he carries with him is heavier, and that he does not wear a double suit.

The diver, with his equipment, should weigh at least 500 pounds. In order that he may not be fatigued by such a weight out of water, he enters a combination of rings, weighted with bars of lead, which are suspended from a U-shaped iron which is itself held by a chain. In this way he can rise and descend without being overburdened by the load. At the bottom of the well, under the moving sand, he has but a slight excess of weight, and after letting go the chain he begins work. If the ooze becomes too thick, he has rather a tendency to rise than to descend, and if it becomes too thin, he must signal to the boat to send less water. The greatest weight is that carried by the diver at his waist. The ring here is formed of two parts connected by a bolt which he can take out himself, thus lightening himself at once by a hundred pounds.

As for the double suit, the use of that has been given up as the result of experience. In fact, it has been found that this suit has the inconvenience of filling with sand, and consequently of becoming very inflexible. It has been replaced by one that remains flexible and prevents undue inflation as well as the double suit does.

The arrows shown in the engraving, in the sand around the well, indicate that the sand is not at rest. Under the pressure of the ascending water it constantly sinks and tends to compress the sides of the well that the water tends to enlarge. There is thus set up a rotary motion, owing to which the layers at the bottom are brought to the surface, and conversely. The trials made with this apparatus at Ymuiden have shown that the sides of sand, under the injection of the water, behave like walls and appear very hard to the touch. The water cannot easily escape because the stratum of liquid sand forms like a cloud on the surface of the well and renders the exit difficult. When we descend into the well, we first meet with quite a thin ooze, and, lower down, near the sand extractor, limpid water and complete darkness.—*Le Genie Civil.*

A COMPANY has been started in Holland, with a capital of 1,250,000 guilders ($500,000), to work the tin mines of Singkep, an island of the Riow Archipelago. Tin has been found at Singkep in large and paying quantities. The new tin mines are to be worked under the superintendence of Mr. Van der Does de Bye, for twenty-two years the chief engineer of the Billiton Tin Mines Company. Machinery is being shipped, and operations are to be carried out on a large scale.

[Continued from SUPPLEMENT, No. 697, page 11136.]

ON WOOL AND FUR, MODES OF CLEANSING THEM FOR THE TEXTILE INDUSTRY, AND ON A NEW PROCESS RECENTLY PATENTED BY MESSRS. SINGER & JUDELL.*

By WATSON SMITH.

II.

WHEN we remember how that the raw wool fiber is penetrated, encrusted, and varnished as it were with yolk and natural grease and soap-like bodies, as well as occasional actual potash soaps, and that woolen cloth and yarn contain oil (as much as 4 to 5 per cent.), and that such greasy matters repel and resist aqueous solutions like those of dyestuffs, the reason for and necessity of scouring processes will be evident.

Scouring, then, is the process of preparation in which the removal of greasy matters, natural or artificial, is involved. For many years, and from the earliest times, stale urine was used for the wool scouring process, but more recently it has been replaced by such solvents as ammonia, sodium carbonate in different forms, soaps, and so forth. Stale urine is an unhealthy and nauseous detergent to use, ammonium carbonate is expensive, with soaps there comes the difficulty that soft waters must be used, or else lime or magnesia soaps will be precipitated in the fiber. Liquor ammoniæ, used, of course, after dilution, is not without risk, for with wools or woolen goods of light color spots or stains may be caused when the ammoniæ is prepared from gas waters. The liquor ammoniæ ought to have been made from good sulphate of ammonia. The question will be asked, "Whence do these gray stains arise?" Doubtless from small quantities of aniline or pyridine bases that have been volatilized and driven over with the ammonia. Before using such ammonias, they should be tested (1) by Kupfferschlager's method—pouring some of the liquor ammonia into a test tube containing some colorless nitric acid diluted with one-fourth its volume of water, partially saturating with ammonia, and observing if a red color is produced; (2) by Ost's method of nearly neutralizing the ammonia with acid, and noticing if an odor of pyridine is perceptible.

Now as to the use of sodium carbonates for wool scouring. Some beautiful as well as cheap salts have been offered and adopted, such as the crystallized sesquicarbonate of Brunner, Mond & Co. and the crystal carbonate of Messrs. Gaskell, Deacon & Co. The first has the formula Na_2CO_3. $NaHCO_3 + 2\,H_2O$, the second $Na_2CO_3 + H_2O$. With magnesian or calcareous waters the earthy carbonates are precipitated on the wool, but are more easily removed by far than earthy alkaline soaps: however, in very greasy wools there may still be risk of deposit of the alkaline earthy soaps. But there is this difficulty with alkalies. Causticity must be avoided altogether, and the carbonates be used very dilute, or the integrity of the fiber is injured. In the first part of my paper it was pointed out that the very finest wools, the merinos and pitchy wools, are just the ones richest in yolk or wool fat. These need proportionately more stress of alkaline treatment to clean them, and there comes the danger. Thus, the finest wools would encounter the most peril. However, in cases where mild akaline treatment can be adopted, no forms of alkali can be safer than the two products named.

We now approach another method, the one more specially interesting to us on this occasion, that of scouring with volatile liquids inert to the fiber. It possesses the essential advantage over the alkaline processes that the wool may be deprived completely of its wool fat without injury to the fiber. However, with all these methods, as so far employed, there are serious objections, either on the score of cost through loss of volatile agent, of modification of the fiber through the manner or under the condition in which the volatile solvent is employed, and through the danger attending the necessity in some stage of the process either for treatment of the fiber or recovery of the spent volatile scouring agent, of the handling of the spent product by workpeople. However, I submit that difficulty and danger are no words to frighten or deter any British manufacturer or workman, when once it is granted that superior results are to be obtained by the use of given means and instruments. Look at our houses furnished with an illuminating agent, coal gas, which, notwithstanding its purification, if let accidentally escape into our bed-rooms, would certainly asphyxiate or poison us, and as if that were not sufficient, convert the atmosphere of our rooms into a dangerous explosive to boot. Note also the fact that the immense volumes of coal gas supplied to our cities are safely collected and stored in capacious vessels of wrought boiler plate, just as the laboratory student collects and preserves his oxygen or hydrogen in the pneumatic trough under an inverted bottle or tumbler.

Do not imagine that I would palliate for a moment any admission of the vapors of bisulphide of carbon, for example, into the atmosphere of sheds or factories or anywhere where they could be breathed by workpeople. I know and have specially studied the poisonous action of carbon bisulphide vapors, and I say that slow poisoning by this agent is simply a terrible thing, involving loss of mind and disease of body combined. But I do not hesitate to say that if a method is offered in which the carbon bisulphide is treated as plant, is to act in the cold, is continually recovered and automatically returned; if it is one in which there is to be no removal of the fetid oil-charged material from the apparatus in which it becomes oil and grease charged, and if while, in a word, the products are discharged at their proper places, the bisulphide simply circulates—then I would on these *prima facie* grounds throw in my adherence to such a method till I heard worse of it.

Let us see what has been done so far with bisulphide of carbon. Several methods have been proposed, and one of the best of recent date is by T. J. Mullings. The wool is placed in a covered-in centrifugal machine and submitted there to the cleansing action of the bisulphide in the cold. When once saturated with the yolk constituents soluble in CS_2, the machine is revolved to extract the chief bulk of it, and the remainder left in the fiber is expelled by water admitted into the apparatus. Water being both lighter than and non-miscible with bisulphide, displaces the latter, which sinks to the bottom of the vessel. The action proceeding in the cold, Mullings claims, and rightly so, that the wool does not acquire the yellow tint invariably assumed when heat is used.

The mixture of bisulphide and water is collected in a tank, and, after settling, the former is run off below, and recovered, by distillation, for using again. Hummel, who refers to the process in his "Dyeing of Textile Fiber," says: "It has been recently tried on a large scale, with a certain degree of success."

Now let us glance at a weak point or two in such a process as this. (1.) In centrifugating the wool from the bisulphide containing these yolk constituents which are dissolved, a time will come when the wool, with a minute quantity, but probably still some, bisulphide left in it, must be exposed, in order to withdraw it, for the admission of water will not remove absolutely all bisulphide. (2.) Since the washing with bisulphide is not by a cumulative system, the bisulphide drawn off for redistilling will not be fully charged with yolk constituents. (3.) Either the dirt and insoluble matters remain among the wool, or are driven out among the bisulphide, or both conditions obtain; this would, in any case, soon necessitate a cleaning out of the centrifugal apparatus, and would increase thus danger and expense.

A modification of Deiss' apparatus for extracting oils from seeds has been proposed. It is a macerating apparatus, in which the wool is treated with warm vapors of bisulphide of carbon. The apparatus is ingenious, but it labors under this disadvantage, that the washing and treatment are not cumulative. Thus the bisulphide in the bulk will not become saturated, and so a proportionately larger volume of this volatile agent must be used for keeping in circulation, per given quantity of wool, than would be the case if a cumulative system were employed.

The annexed figure (Fig. A) represents Deiss' apparatus, which is very much used on the Continent. A store well contains the bisulphide of carbon (covered with a layer of water), and also acts as receiver for the bisulphide when recovered by distillation from the oil and bisulphide mixture which has reached the retort. By means of a pump, the bisulphide is raised to the macerator, where it comes in contact with the seeds or other materials from which oils are to be extracted. Here it is heated in contact with the seeds or other matters by a dry steam coil, the bisulphide vapors evolved being caught and condensed in the worm, and so returned to stock in the well. When the extraction is ended, the seeds, etc., remain on the false bottom of the extractor or macerator, while the oil-laden bisulphide is passed over to the retort by the pipe shown at the upper part of the extractor, where the specifically lightest layer, that richest in oil, is. In the retort it is heated by closed steam, bisulphide returned to stock, and oil remaining in the retort, to be afterward drawn off. When the bisulphide of the first treatment is run to the retort, the seeds and macerator must receive a final treatment, resulting in a dilute solution, which must then be treated in the retort.

Not only Deiss' modified apparatus, but many others proposed, suffer from this defect, the force of which you will easily recognize when I compare it, as to its result, to the lixiviation of a quantity of black ash or crude soda, all in one and the same black ash vat. It would mean non-saturation, a lot of weak liquors, larger consumption of fuel, increased labor.

In many of the processes proposed, a great difficulty again has been the putting in of a charge of wool to an apparatus which must be opened for the purpose, and the withdrawal after washing, which is likely to be just as disagreeable and dangerous.

Not the least of the difficulties is the treatment of the dirt and sand separated from the wool, and containing, at least, some little of the bisulphide. And now, last and not least—and I speak as an old manufacturer of carbon bisulphide—the difficulty of distilling the bisulphide from the oil completely and securely, and moreover of separating, as in the case of Mullings' apparatus, the oily bisulphide from the water with which it is mixed, to do all this safely and without loss, which would mean danger even if but a very modest loss, involves the solution of practical problems of no ordinary magnitude.

I think we now see that if an effective and safe apparatus is to be put into the hands of the wool scourer, it must in working fulfill conditions something like the following: It must consume as little bisulphide per given quantity of wool as possible, *i. e.*, it must return nothing but a bisulphide as nearly saturated with yolk constituents as possible. The saturated solvent must proceed direct and covered to the still for regenerating from it the CS_2, and that carbon bisulphide must be condensed and pass again direct into the washing system. The still must be one that can work automatically, like the rest of the apparatus, and work safely. It must deliver the oil, free from bisulphide, continuously and automatically as it is produced. Hence, and in other words, the carbon bisulphide must circulate through and around the entire system, including *the recovery still*, and drop the oil, so to say, on its way, and at its proper place.

But to this end the very dirt and sand deposited from the wool in the apparatus must also be automatically gathered up, and what is more, it must be as automatically washed with bisulphide (fresh) and then be rid of all traces of carbon bisulphide, which must be returned to circulation in the system, while the dirt and sand are automatically and continuously delivered at a specific and proper place.

The washing with water should take place in the same apparatus, and the washing should also admit of the same continuous and cumulative action as with the bisulphide. If possible raw wool must be delivered into such apparatus at one place by some simple process that workmen will easily understand, and the thoroughly washed wool must emerge at another, just as simply as the oil and grease are, and also the dirt and sand. Finally, no direct fire must be necessary anywhere near this apparatus, which may consequently be to a considerable extent isolated.

I shall now describe such an apparatus to you, and it is the one we are assembled to-night to hear about, by Messrs. Singer and Judell, of Adelaide. It gives me pleasure to add that Mr. Ignatius Singer is also present, and will be able to answer any questions that I may fail to reply to.

The raw wool is first deposited on an endless belt made of wire gauze (Fig. B, also Fig. C, *f*), down upon which comes another belt, forming an upper cover, to hold down the wool just as the belt enters the apparatus, which is a structure of iron, measuring, for an output of 50 to 60 bales per 24 hours, about 35 feet long. All lids, covers, etc., are securely luted in water. It will be observed that the top belt, as the washed wool emerges, becomes the bottom belt bearing the fresh charge of raw wool as the double belt re-enters the apparatus. The double belt, bearing the raw wool clasped in it, now descends into the first of a series of cells or cisterns, which, when the apparatus is in work, is empty, when out of work is filled with water to lute the edge of the cover of the apparatus dipping into it (Fig. C). Passing into this first cell the belt passes over a roller, under another at the lower part of the cell, and then rises under the cover lid and passes between two squeezing rollers. The band with its wool now descends into the first carbon bisulphide vessel (Fig. B, and also Fig. C), and emerging is squeezed between nipping rollers just before entering the second cell.

Thus, it travels through and is washed and squeezed in 14 cells containing carbon bisulphide, when it enters five similar but deeper tanks containing water alone, in which it is also washed and squeezed (Fig. B). The band with wool now ascends to a drying chamber, and in its upward course is supported and run upon two rollers. In this chamber it passes upward and downward over hollow rollers, heated internally with steam, and it is also squeezed between the hot rollers. At length the band emerges bearing washed and dried wool. The top band now departs horizontally to a more distant roller before descending; the lower one bearing the wool, passing over one nearer at hand, descends sooner and lets the wool fall into a suitable receptacle or shoot, and turning around another roller lower down, re-enters the apparatus as top band to that band which previously separated, and now, reladen with fresh raw wool, re-enters as bottom band (Figs. B and C, *f*).

We have thus followed the mere course of the wool and observed that this is characterized by a continuous automatic action. Let us now follow the course of the gaseous currents, for what must immediately strike the imagination is the fact that the first cell is open, and the lid of the apparatus dipping into it is not luted when operating (only luted in water during quiescence of the machinery).

Carrying the eye to the drying chamber above, a pipe, wide in its upper part and communicating with a cylindrical worm condenser, is noticed. In that wide pipe a draught is created by the aspirating action of a fine water jet or spray under pressure at *b* (Fig. B). This draught, however, is but a gentle one, something like that produced in a vitriol chamber system. It is just sufficient to prevent carbon bisulphide vapors from receding and passing under the lid or cover dipping into the empty tank or cell into which the wool band first enters. It is also sufficient to carry the vapors of bisulphide from the drying chamber to the condensing worm, where those vapors are condensed and so recovered, and returned to the system. The connection between the atmosphere of the bisulphide cells and the drying chamber is by means of a draught pipe furnished with a tap, *e*, shown in Fig. B. We notice then the general motion of the atmosphere of the system is in a direction from the entrance of the wire band, with the same, and toward the water jet and condenser. All carbon bisulphide vapors in the entire system then tend toward and pass down the condensing worm, then returning to the "dividing cistern," dividing bisulphide from water, *d*, Fig. B.

Let us now see what becomes of the dirt deposited from the wool. From the wool, so soon as the carbon bisulphide dissolves out the wool grease, etc., the dirt at once falls out of the wool and sinks to the bottom of the vessel. I will show you how this takes place by a small experiment in a stoppered funnel, in which I have placed some raw wool. I pour in some carbon bisulphide, and while this liquid is effecting solution, you may perceive the dirt dropping out of the wool. Now through each of the first six bisulphide cells or tanks (see Fig. C and also Fig. D) works an endless chain of perforated dredgers. The bottoms or dirt of the cells are thus continuously dredged up, the oily bisulphide draining back into the cells during the upward motion of the little dredging buckets. These buckets, just on their descent and consequent reversal, empty their contents into a gutter of semicircular section, *h*, Fig. D, through which an endless screw agitator works (see Fig. C, *e e*).

The screw works the dirt and sand, containing still some oily bisulphide, in a slightly upward direction along this gutter, and meanwhile an isolated dredging system, precisely similar to the six already mentioned, only that it is furnished with non-perforated buckets, and which is fixed to the tenth bisulphide cell, brings up continually a fairly pure bisulphide and empties it into the gutter with sand, dirt, and still some oil (see Fig. B). The bisulphide runs along by its own gravity back toward the first cell, and in a contrary direction to that of the motion of the sand and dirt, which it continually washes.

The washings continually flow into the first tank, which contains the most contaminated or highly charged bisulphide. The washed sand and dirt, pushed on by the screw, at length enter a down pipe (Fig. B, and also Fig. D, *h*), where they drop into a retort (not visible in the drawings) connected with a Liebig's condenser. They are subjected to heat in this retort, when the bisulphide passes over and is condensed and returned into the delivery main along with the other supplies of bisulphide at *c*, Fig. B.

The retort consists of a long pipe in which works an endless screw. This retort is double steam jacketed, and the end is connected with an aspirator to draw off the CS_2. The sand and dirt drop out at the end. But let us further follow the course of the vapors to the point of their recovery. I have said that not a steam jet but a water spray jet creates the suction or draught carrying the vapors into the worm (*b*, Fig. B), which commences, according to strictly scientific principles, wide, and gradually tapers down as cooling and condensation proceed. The condensed liquid falls from the worm into a small collecting space, runs by a pipe to the bisulphide main *c*, Fig. B, where it joins the stream coming from the recovery still to be afterward described. The bisulphide then falls into the cell or tank at the end of the tank system, where it settles down as a lower layer under water. The air draughted

* Read before the Chemical Club, December 4, 1888.

through the system escapes by the central vertical pipe fixed above the collecting space in which the worm terminates. The minute quantity of bisulphide escaping with the air it is not considered worth while to collect. The top of this shaft is fitted with a cover valve which is closed when the apparatus is not working.

Let us now see how the carbon bisulphide is distributed and the water disposed of in the last tank receiving the recovered solvent. The overflow siphon tube for the bisulphide is one which every tar distiller is accustomed to for separating the bottom water layer in his receivers from the supernatant one of naphtha (Fig. E).

However, in such cases the lower layer, the water, is valueless, and is run off to waste, but in our present case the lower layer is the one of a principal value. We need, then, an automatic arrangement for preventing the level of the CS_2 from rising above a certain point, or we shall incur the risk of getting bisulphide

Fig. A.

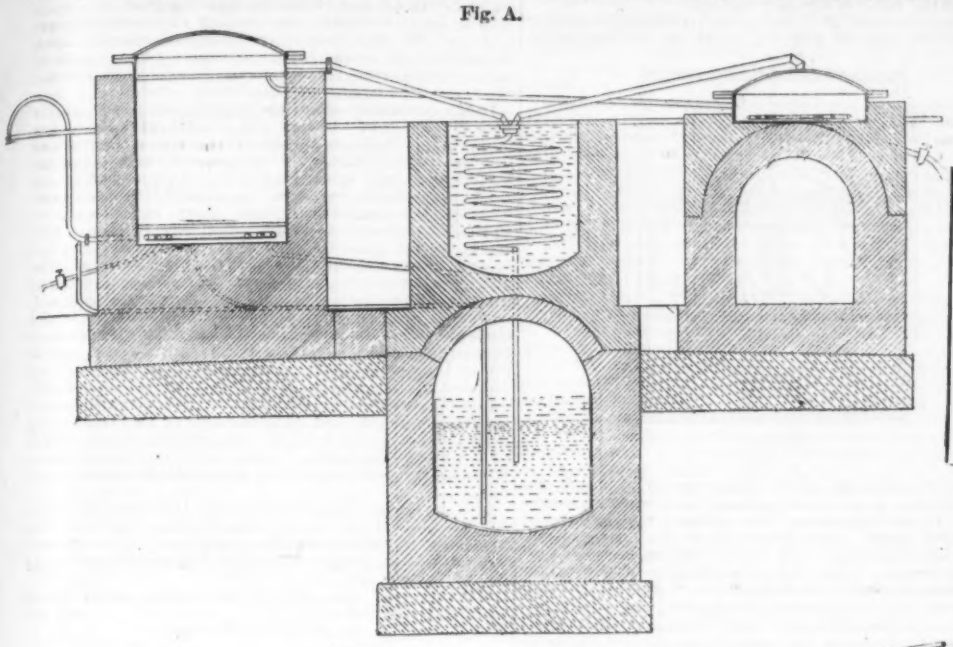
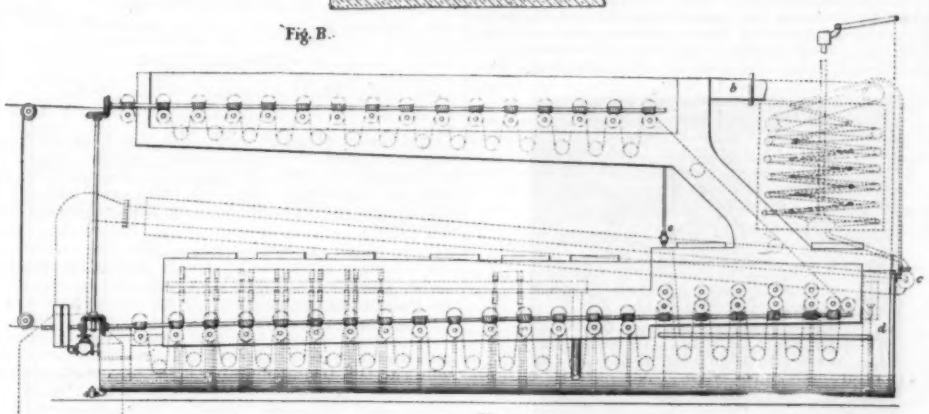
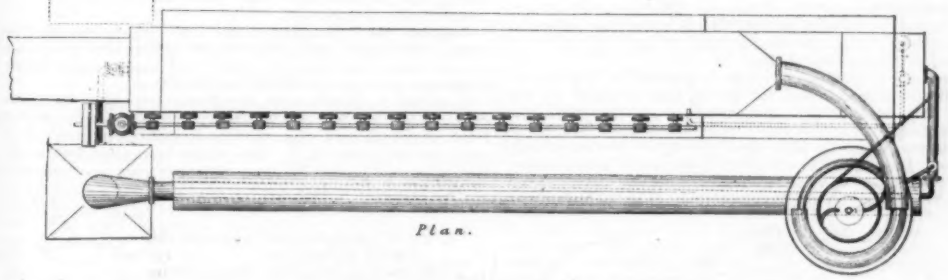


Fig. B.

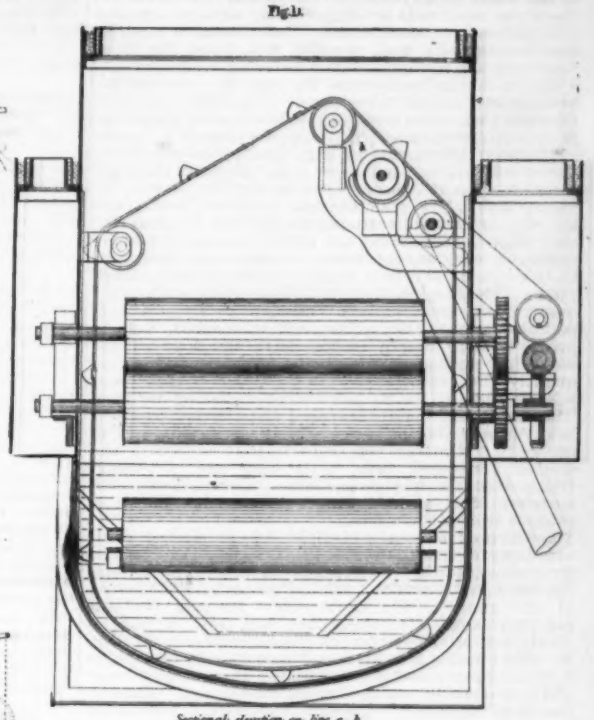


Elevation.



Plan.

Fig. D.



Sectional elevation on line a. b.

Fig. E.

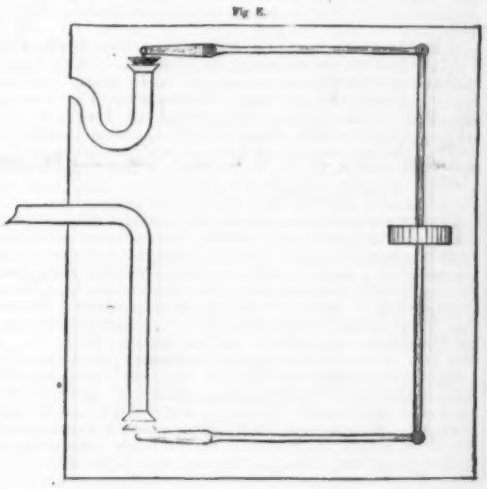
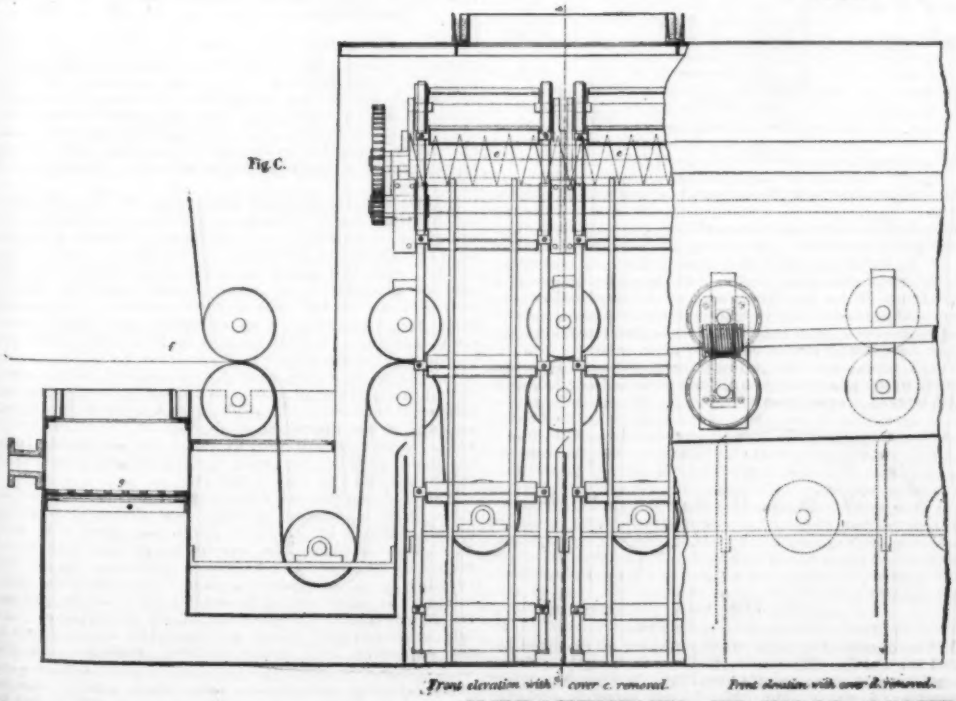
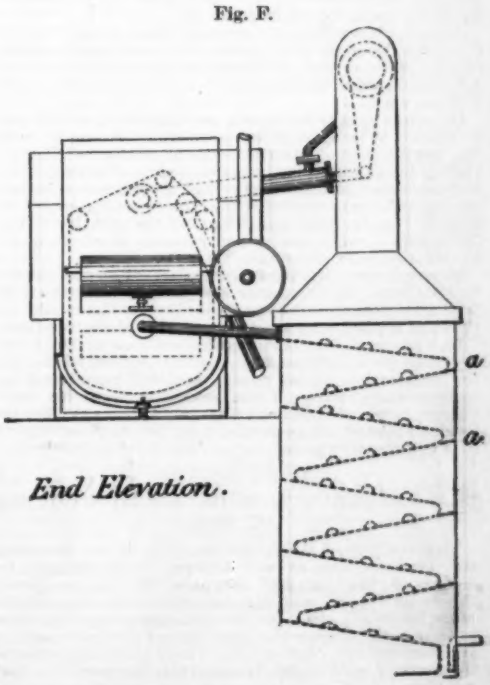


Fig. C.



Front elevation with cover c. removed. Front elevation with cover B removed.

Fig. F.



End Elevation.

IMPROVEMENTS IN WOOL SCOURING.

returned in the upper, the water overflow. Messrs. Singer and Judell have adapted a highly ingenious arrangement for this purpose, so that it is quite impossible for the level of carbon bisulphide and water layers to be other than constant. The carbon bisulphide overflows into and supplies the bisulphide tank nearest to the water tank system, and the water overflows into the water tank next to the receiving or dividing tank with automatic contrivances. This automatic contrivance consists of a float (see Fig. E and also Fig. B, *d*) which sinks in the water of the receiving tank but floats upon the carbon bisulphide. Through it, above and below, passes a slender rod with swivel joint at either end, connected with the terminals of two levers, whose opposite ends are armed with stoppers closing or opening respectively the water and bisulphide overflows, above and below. It is now manifest that when adjusted for a particular level of bisulphide in the "divider," if that level rose the float must rise, would raise the ends of the two levers connected with its axial rod, and these levers acting on their fulcrums would respectively close up the water overflow pipe and open the bisulphide overflow siphon (which delivers bisulphide to the bisulphide tanks just as water is siphoned over from a tar distiller's "divider"). Thus a compensating automatic adjustment is secured, and, in principle, it is closely analogous to the float adjustment for regulating the steam pressure, and consequently the temperature, in distilling benzene and toluene, etc., in the Savalle's dephlegmating column. The water and bisulphide then respectively overflow into the neighboring tanks for these liquids, and so move in a direction opposite to that in which the double perforated belts with wool are traveling. Hence wool that has become cleaner always meets with a current of bisulphide that is purer still. The same thing is true of the water.

Let us now follow the bisulphide in its course. This overflows from tank to tank till it reaches the first cistern, when, flowing underneath the inner cell holding the band and rollers and passing through a fine strainer of wire gauze (*g*, Fig. C), it enters through the exit pipe, furnished with regulating tap (Fig. B), and is slowly fed into the retort, of special construction (Fig. F). The interior is so arranged that the oily bisulphide flows down grooved sloping plates, along the bottom of the grooves of which a steam pipe is laid. The oil, free from bisulphide, at length reaches the bottom of the series of plates or trays in the retort, when it collects in the little cistern and overflows by the siphon pipe, as shown in Fig. F. At the sharp, almost angular curve made where one groove joins the next on a sloping tray, the steam pipe, to prevent obstruction of the flow of oil, making a small arch or bridge, enters the next groove lower down and again lies along the bottom of it. These small arches are shown at *a*, *a*, Fig. F.

Allow me now to point to two or three apparently trivial devices in chemical engineering which, nevertheless, are calculated to astonish us by the important results achieved by them. Notice first (Fig. B, and also Fig. C) the sloping summits of the respective inner and outer false sides of the carbon bisulphide tanks. It will be observed that the slopes increase the depth of the tanks, while they guide and drain the expressed liquors from the rollers down again into the proper tanks, so that those tanks containing purer bisulphide are not contaminated by bisulphide drainings from a less pure tank nearer to the final and most highly charged tank. Besides this, by increasing the depth of the tanks in the manner described, an opportunity is afforded for the most highly charged bisulphide in each tank, which is consequently of *lowest* specific gravity, to overflow into the neighboring tank in the most economically advantageous way, viz., at the top, and with the same advantage, to enter that neighboring tank at the bottom. In the case of the water tanks, a similar arrangement is devised, but since the water most highly charged with saline matters, etc., will possess the highest specific gravity, and so lie nearest the bottoms of the tanks, the overflow takes place from the bottom of one tank and by the top of the next one into which the liquor runs over. This is made plain in Fig. B.

This is not an apparatus that has been merely worked out on paper. It has been very carefully operated in Australia for some time by the inventors, and I am assured that in the neighborhood of the scouring plant no smell whatever of carbon bisulphide can be detected when the apparatus is in full work.

A patent has still more recently been taken out by G. and A. Burnell, of Adelaide, for a very similar piece of apparatus to that of Messrs. Singer and Judell, but it is one in which it is proposed to use benzine or petroleum spirit.

In using petroleum spirit, a rectification would first be needed to free the ordinary spirit of the trade from the partly greasy, partly resinous bodies of higher boiling point which it always contains. I miss in Burnell's specification any account of a continuous distilling apparatus to restore fresh solvent and give a continuous supply of oil, and I fear for the security of the leather-lip arrangement to "prevent as much as possible the escape of the fumes."

Messrs. Singer and Judell calculate that the profits derived from the by-products of their process (the wool fats and potash salts, etc.) should pay the whole expense of royalties, apparatus, and bisulphide required.

In conclusion, my best thanks are due to Dr. F. H. Bowman for kindly lending me his lantern slides for the illustration of my papers, and for permitting me to reproduce some of the woodcuts from his well-known work on the wool fiber, also to Mr. Ig. Singer for drawings of his apparatus and for other assistance in preparing this paper.—*Jour. Soc. Chem. Industry.*

THE DETERMINATION OF A SHIP'S COURSE AT SEA.

THE position of a ship at sea, that is, its longitude and latitude, can, as well known, be determined by means of the log and compass, the former giving the vessel's speed and the latter the direction of the route followed. But, for this, it is necessary from time to time to determine the direction of the compass by an astronomical observation, which much complicates the method, and which, moreover, is impossible in bad weather.

This has led Mr. Berg to devise a method that permits of determining the ship's route with the same precision as by astronomical observations, but with the help of the compass and log solely. This method only requires that the pilot shall cause the ship to describe a circle. During this evolution, the deviations of the compass are inscribed upon a registering apparatus which is the basis of the new method.

This apparatus (Fig. 1) comprises four compartments, viz., the two cameræ obscuræ, A, B, the photographic

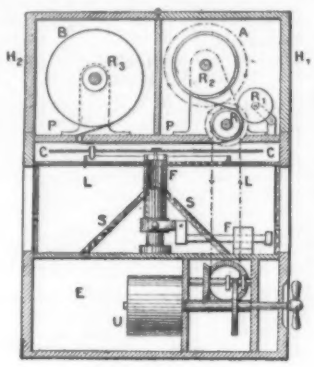


FIG. 1.

compartment, C, the light compartment, L, and the compartment, E, in which is placed the clockwork movement. In the chamber, B, is placed the supply of sensitized paper. The drums, R R, that carry along and guide this paper are in A, and are actuated by the clockwork. Upon the circumference of the drum, R, there are a certain number of points which penetrate the paper and thus prevent its slipping, and which, besides, mark a straight line upon the paper that must pass exactly through the axis of rotation of the compass. As the distance of these points serves to measure the time, their number and the diameter of the drum depend upon the unit of time adopted. The

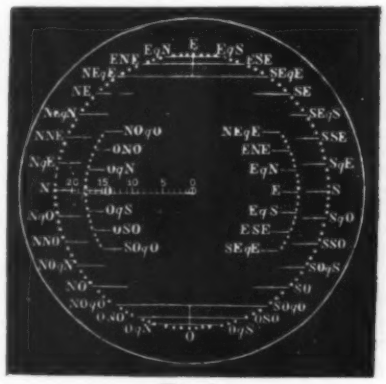


FIG. 2.

paper winds around the drum, R_2, after the registering, and, as the diameter of the drum varies according to the quantity of paper wound, the drum is coupled by friction with the wheel, R_1.

The rose, *c*, of the compass is placed in the photographic chamber, upon its pivot, and is fixed by the part, F, as long as the apparatus is not in operation. In its magnetic axis it has a cylindrical aperture, which allows the light to pass and act upon the sensitized paper. The indications of the compass are, besides, engraved upon the lower surface, and the direct readings are effected through the mirrors, S M. All the parts

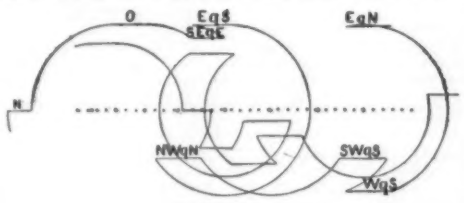


FIG. 3.

of the apparatus, save the magnet, are of non-magnetic metal.

The registering done upon the under surface of the paper gives reversed indications. For example, if the paper be turned around the axis of the compass, from N to O, the registering point will describe an arc of a circle from N to E. This is why it is necessary to change the paper's position in order to obtain confirmable indications, and this has necessitated the placing of the registering paper over the wind rose.

Fig. 3 represents the indications engraved upon the surface of the glass disk employed for reading the registered curves, a specimen of which is shown in Fig. 3.

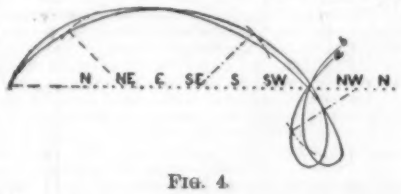


FIG. 4.

Let us consider a ship whose rudder is directed toward the north. Its course, that is, the angle between its axis and the magnetic meridian, is then inscribed upon the paper as azimuth. If the latter is easterly, it is marked to the right of the axis of the registering apparatus, and *vice versa* if westerly. The glass is then so placed that N of the straight line, N S, shall be directed toward the beginning of the curve. The course followed by the ship in such or such a phase of the registering is then determined by observing the coincidence of the segments, of the ordinates of the curve inscribed, and of the deciphering glass.

In order to facilitate the reading of the curves east and west, the wind rose is provided with a second aperture nearer the center than the first, but a quarter-circle distant with respect to the latter. Figs. 2 and 3 show the advantages of this.

In the apparatus described above, the paper moves with a velocity of 0·08 inch per minute, and every five minutes a point separates the intervals of the teeth of the unwinding drum. The duration of each revolution is thus measured upon the axis of the paper band.

The apparatus registers the course of the compass, and not the magnetic course. Now, it is the latter that it is necessary to know. For this, it is only necessary for the pilot to move the rudder a few degrees so as to cause the ship slowly to describe a circle. The apparatus would then describe the curve, *a*, were its magnet submitted to the action of terrestrial magnetism only; but, in consequence of the magnetism of the ship, the curve described is not so regular, and becomes the curve *b*. The deviation of the compass corresponding to a given azimuth is then found in the following manner: The duration of the ship's evolution is divided by the number of divisions of the wind rose, and this division is carried upon the axis of the registering paper, between the first and last position of the center of the inscribing radius. There is thus obtained upon this axis the positions of the principal divisions of the rose.

If it be desired to know the deviation of the compass for its division, S O, for example, the center of the glass disk is placed upon the point, E, of the axis, and the number of degrees comprised between the curve of the deviations and the curve described by the apparatus is then read upon the periphery of the glass. Thus, in Fig. 4, the deviation for N E is + 17° E, and for NOqN, — 19O.—*La Lumiere Electrique.*

EXPLOSIVES.*

By W. H. DEERING, F.C.S., F.I.C.

GUNPOWDER.

IN the case of gunpowder, there has been the important innovation of brown or cocoa powder, introduced in Germany in 1882. Previously to that date the gunpowders in military use were black, and had the following composition (the moisture always present being deducted):

	Nitr. Potass. Nitrate	Sulphur.	Charcoal.
England	75	10	15
France (cannon powder)	75	12·5	12·5
Germany	74	10	16
Austria	75·5	10	14·5

The brown powder, however, has the composition of 79 per cent. potassium nitrate, 3 per cent. sulphur, and 18 per cent. charcoal. This is the composition given in Mr. J. N. Heidemann's patent (Eng. pat. Dec. 11, 1884, No. 16,314), where it is further stated that the brown carbonaceous substance used as charcoal is obtained by carbonizing straw until it attains a brown, chocolate-colored appearance, when it is cooled, powdered, and mixed with the niter and sulphur in the proportions mentioned.

Used in the prismatic form, the brown powder (for equal velocities imparted to the projectile) produces considerably less pressure, and less smoke, than black prismatic powder of the old composition.

Captain A. Noble and Sir Frederick Abel, in their researches on fired gunpowder, found the quantity of heat evolved, and the volume in cubic centimeters of permanent gases (*i. e.*, the water being condensed to liquid) at 0° C., and 760 mm. pressure, per one gramme of dry powder, to be:

	Cocoa prism.	Black pebble.
Units of heat evolved (gramme degrees Centigrade)	837	721
Volume of permanent gases (cubic centimeters)	198	278

The cocoa powder, then, gives on explosion a greater quantity of heat, but a less volume of permanent gases, than the black powder. The larger quantity of water vapor produced in the case of the brown powder would, from its high specific heat, also have some influence in lowering temperature, and consequently pressure; but the lower pressures produced in the gun with brown powder must be largely attributable to a slower rate of combustion.

Brown powder contains more niter and less reducing matter than black powder; and the saline residue produced by its explosion is completely oxidized, and consists of potassium carbonate and sulphate, and no sulphide; and the gases of explosion contain a much smaller proportion of incompletely oxidized constituents than in the case of black powder. The latter gives, when exploded, a considerable quantity of potassium sulphide. I shall be able to show this difference in chemical composition of the residue by inflaming, in these plates, an equal weight of black and brown powder; much potassium salt goes off in the powder smoke, but we will dissolve the residues in a little water, filter, and add to the filtrates lead acetate solution and acetic acid, when we shall obtain black lead sulphide from the black powder, and only white or slightly gray lead sulphate from the brown powder.

Amide Powder.—An explosive preparation for use in guns, or as a blasting powder, was patented recently in this country by F. Gaens (Eng. pat., year 1885, 24th Nov., No. 14,412). The specification contains some points of interest; the patentee proposes "to replace sulphur by an ammonium salt, in combination with saltpeter in such proportions that on ignition potassamide is formed—a compound which is volatile at high temperatures, and which increases the useful effect of the explosive, and burns without residue." In the

* A paper recently read before the Society of Arts, London. From the *Journal* of the Society. For an additional paper on same subject see SCIENTIFIC AMERICAN SUPPLEMENT, No. 406.

case of ammonium nitrate, he gives as the fundamental equation :

$$KNO_3 + H_4N.\ NO_3 + 3C = KH_2N + H_2O + CO + 2CO_2 + 2N,$$

according to which the amided powder would consist of 101 parts by weight of potassium nitrate, 80 parts of ammonium nitrate, and 40 parts of charcoal ; and the explosive prepared in such proportions is stated by the patentee to leave very little, if any, residue when burned, to produce no gases injurious to the gun, and much less smoke than ordinary gunpowder. He states that other ammonium salts than the nitrate may be used, keeping to such proportions as to produce amide on explosion of the mixture.

I have not, however, been able to find in chemical literature the volatility of a potassamide recorded. We have to go back to the time of Gay-Lussac and Thenard, and of Davy, for what information we have on the subject. They describe a monopotassamide, KH_2N, and a tripotassamide or nitride of potassium, K_3N, the latter formed by heating monopotassamide to redness in a closed vessel, $3KH_2N = K_3N + 2NH_3$. Davy says that it (the tripotassamide, K_3N) separates at a very high temperature into potassium and nitrogen gas.

Probably the valuable properties of such a powder as that proposed in this interesting specification could be explained on other grounds.

In respect to the use of ammonium nitrate in gunpowder, but not in the same direction as in the patent just referred to, I may mention that Dr. H. Sprengel, in 1873, observed that an increased initial velocity was imparted to a rifle bullet when a mixture of ammonium nitrate and charcoal was substituted for a portion of the gunpowder charge (Dr. Sprengel used sporting powder—*Journal Chemical Society*, 1873, p. 805) ; and that the powder used in 1887, in the cartridge of the Swiss 7·5 mm. Hebler rifle had ⅛ths of the usual potassium nitrate replaced by ammonium nitrate ("Mittheilungen über Gegenstände des Artillarie und Genie-Wesens," year 1888, p. 289).

GUN COTTON.

Since Sir Frederick Abel's method of treating gun cotton, by reducing it to pulp, thoroughly washing and mixing it in water by a paddle wheel, and subsequently strongly compressing the pulp into cylinders, slabs, etc., by hydraulic pressure, comparatively little has been done in the manufacture and treatment of gun cotton. Von Forster and Wolff, in 1883, patented the treatment of moist or dry gun cotton by immersion in a solvent, such as acetic ether or nitrobenzene. When a piece of compressed gun cotton is immersed for about half a minute in acetic ether, then exposed to the air to allow the solvent to evaporate, it becomes coated with a thin but hard skin of dry gun cotton. Von Forster proposed applying this to moist and to dry compressed gun cotton, to retain the water in the former case, and to exclude it in the latter, by a waterproof coating formed by gelatinizing the gun cotton by acetic ether. This coating was, however, found to have minute cracks in it, so that he subsequently coated his dry gun cotton primers externally with paraffin, the hole for the detonator alone being gelatinized by acetic ether (so as not to diminish its sensitiveness to detonation). In recent experiments with gun cotton shells in Germany and Italy, those forms of shell which had to be charged through their fuse hole were filled with log-shaped pieces of moist gun cotton (about 1 to 2 inches long, with sides of 0·4 in. to 0·7 in.), sawn from wet compressed slabs, and which had been coated by dipping into acetic ether ; the chamber of the shell was then filled with a mixture of equal weights of paraffin and carnauba wax, melted, and at a temperature of about 180° Fah., poured in through the fuse hole.

NITROGLYCERIN.

In the preparation of nitroglycerin explosives, much has been done since 1875. The most noteworthy invention in this important group of explosives has been Mr. Nobel's *blasting gelatin*, introduced, I believe, in 1879. This well known explosive is composed of about 93 parts by weight of nitroglycerin and 7 parts of nitrocotton ; the latter is less highly nitrated than gun cotton. The nitro-cotton is dissolved in the nitroglycerin contained in a copper vessel, and maintained at a temperature of 95° Fah. by means of warm water. The mixture is kept mechanically stirred during the heating ; the nitro-cotton dissolves, and a mass of the consistence of thin dough is obtained, which stiffens on cooling.

Here is a cartridge of blasting gelatin of Ardeer make ; it is a brownish yellow, semi-transparent, gelatinous substance. Its specific gravity is but little less than that of nitroglycerin, which is 1·6. It does not break up nor part with its nitroglycerin when immersed in water, as does kieselguhr dynamite, which is a great advantage ; it requires, however, a stronger detonator than thawed kieselguhr dynamite, and detonation is not propagated through a train of blasting gelatin cartridges freely exposed, as in the case of dynamite. Its power as an explosive is about half as great again as that of kieselguhr dynamite (of 75 per cent. nitroglycerin), and where applicable there would be economy in its use, as compared with the latter explosive.

Nitroglycerin contains more oxygen (3·52 per cent.) than is required for its complete combustion to carbonic acid and water, while dinitrocellulose is deficient by 44·4 per cent. oxygen for complete combustion, so that blasting gelatin contains the amount of oxygen required for complete combustion.

A cold process for gelatinizing nitroglycerin by means of collodion nitro-cotton was patented in 1887 by the *Deutsche Sprengstoff-Actiengesellschaft* of Hamburg (D.R.P., No. 42,452 ; Eng. pat., No. 2,318). The cold gelatinizing was to be effected by dissolving picric acid (up to about 10 per cent., the quantity depending on the quantity and quality of the nitro-cotton employed, and the required consistency of the jelly) in the nitroglycerin and adding to this solution finely powdered or ground collodion nitro-cotton, the gelatinizing being assisted by frequent stirring. Pure tetranitrocellulose (probably what is generally called dinitrocellulose, $C_6H_8(NO_3)_2O_5$, is meant) is said to dissolve in two days. The proposed process is interesting, but it is questionable whether it is in actual use.

Gelatin Dynamite was introduced comparatively recently by Mr. Nobel. The No. 1 grade consists of 65 per cent. of a thin blasting gelatin and 35 per cent. of a combustible mixture ; the No. 2 grade contains 45 per cent. and 55 per cent. respectively. The gelatin consists of 97·5 per cent. of nitroglycerin and 2·5 per cent. soluble nitro-cotton ; the combustible mixture of potassium nitrate 75 per cent., wood meal 24 per cent., sodium carbonate 1 per cent. *Gelignite* is a variety composed of 60 per cent. of a thin blasting gelatin (56·5 per cent. nitroglycerin and 3·5 per cent. nitro-cotton), 32 per cent. potassium nitrate, and 8 per cent. wood meal.

These are cartridges of gelatin dynamite and of gelignite ; they are elastic gelatinous substances, and will bear immersion in water without parting with their nitroglycerin.

Experiments of Sir Frederick Abel's give the power (or intensity of action), when suitably detonated, of gelatin dynamite, No. 1 grade, of recent Ardeer make, as = 127, another experiment gave 123, mean = 125. He found the power of gelignite to be 100 ; kieselguhr dynamite, No. 1, of 75 per cent. nitroglycerin, from the same source being = 100.

I will digress to mention that these estimations of intensity of action were made by detonating an ounce of the explosives (or 1½ oz. in some cases) in the bore hole of a large cylinder of soft lead. Sir Frederick Abel has used the method since 1878, employing large cylinders 12 inches high and 12 inches in diameter, having a central cylindrical hole, 7 inches deep and 1·3 inches in diameter. A 1 oz. gun cotton primer just fits the hole ; explosives of the consistence of dynamite are compressed in it by means of a wooden rammer; cast or compressed charges are filed to fit the hole. The cylinder is made to stand on a wrought iron plate, the explosive placed in the charge hole, and suitably provided with a fulminate of mercury detonator, or with fulminate detonator and intermediate priming, such as may be necessary to obtain the maximum effect ; the charge hole is then filled with fine dry sand, poured in (not compressed) and around the insulated wires in the usual case of the charge being fired electrically. There is usually a column of about six inches of sand. The detonation of an explosive susceptible of it takes place with great rapidity, so that the amount of enlargement of the charge hole (ascertained by measurement with water before and after the explosion) gives a measure of the combined effect of the pressure produced by the detonation of the explosive and of its rate of detonation. In the case of a very inert explosive needing strong confinement, a shell would be charged with it, buried in earth, and detonated electrically, and the crater produced measured ; or the shell detonated in a suitable cell, and the number and weight of the fragments noted, comparative experiments with gun cotton or dynamite being made in these cases, as in that of the lead cylinders.

Carbo-dynamite is an explosive, the invention of Messrs. Borland and Reid, and patented by Mr. W. D. Borland in 1886 (January 18, No. 758), in which the nitroglycerin is absorbed by cork charcoal. From the statements made, the cork charcoal appears to have remarkable absorbing power. The patentee recommends the material obtained by incorporating about eight parts (by weight) of nitroglycerin with about one part (by weight) of cork charcoal, as convenient of manipulation. It is stated that no nitroglycerin is separated from this preparation by immersion in water for several months. I have arranged here cylinders of water, in which are suspended tubes open at both ends, containing kieselguhr dynamite, blasting gelatin, gelatin dynamite, and carbo-dynamite, showing the retention of the nitroglycerin by the last three, and the breaking up of the first named explosive. An account is given in *Engineering* of April 20, 1888, of some experiments with carbo-dynamite, from one of which—comparative detonations in lead cylinders (on a smaller scale than in the experiments referred to above) of carbo-dynamite and ordinary kieselguhr dynamite—the carbo-dynamite used (stated to contain 90 per cent. nitroglycerin) gave a result such as would have been given by blasting gelatin, which explosive it resembles in its high percentage of nitroglycerin, but from which it differs by its other constituent being non-explosive, and by its being deficient in oxygen for complete combustion into carbonic acid and water. Mr. Borland also claims that the addition of 3 per cent. cork charcoal to kieselguhr dynamite (of 75 per cent. nitroglycerin) enables the preparation to bear immersion in water without parting with its nitroglycerin.

Further, the inventor claims that by incorporating carbo-dynamite (by kneading) with one-fourth of its weight of water, a dynamite is produced which is uninflammable, but which can be exploded by a suitable detonator ; also that under these circumstances the product so obtained detonates without flame, rendering it a safe explosive for use in coal mines.

Mr. Nobel's gelatinous nitroglycerin preparations are said to be replacing kieselghur dynamite. They are largely used in coal getting in conjunction with an envelope of water, forming the "water cartridge." The object of using an envelope of water is the suppression of flame or sparks from the explosive itself, and the prevention of the heating to incandescence of particles of the tamping employed, or from the sides of the borehole. This use of a water envelope with a high explosive is due to Sir Frederick Abel ; he had in 1873 used water as the medium for conveniently transmitting and causing to act on a considerable surface the pressure caused by the detonation of small charges of explosive, and subsequently (in 1880-81), with Mr. Smethurst, he made the extinguishing action of a water envelope the subject of experiment in collieries near Wigan. The results obtained then, and afterward, for the late Royal Commission on Accidents in Mines, those made by the Prussian and Saxon commissions, and the experience obtained in collieries where a "water cartridge" is used with gelatin-dynamite as the explosive, justify confidence in the safety given to coal blasting by the suitable use of a water envelope round the explosive (the volume of the water must be at least four times that of the explosive), especially when the latter is of the gelatin dynamite type ; the charge being fired electrically, or by other safe means.

E. D. Muller has patented (Eng. pat., Sept. 13, 1887, No. 12,424) the mixing of salts containing a large amount of water of crystallization with ordinary nitroglycerin explosives ; with a kieselguhr dynamite, or a dynamite with a combustible absorbent (*e. g.*, wood meal and a nitrate) ; or for hard coal and inflammable coal dust, with fire damp also present, he uses a mixture of blasting gelatin or gelatin dynamite with the hydrous salts. (The nitroglycerin may be partly replaced by nitrotoluene, nitrobenzene, or nitronaphthalene.) The hydrated salts are to contain at least five molecules of water of crystallization, and those more particularly recommended are soda crystals ($Na_2CO_3 10HO_2$) or sodium sulphate ($Na_2SO_4 10H_2O$), or for use in warm climates or warm places magnesium sulphate ($MgSO_4 7H_2O$), as being less liable to lose its water. These salts contain respectively 62·9 per cent., 55·9 per cent., 51·2 per cent. of water of crystallization ; they are to be mixed in the state of powder with the explosive, in such proportion that the resulting compound shall contain 15 to 65 per cent. of the hydrated salts. The mixture is made into cartridges. These preparations have received the name of "wetterdynamit," or fire-damp dynamite, and very promising results in respect to the safety for blasting in the presence of fire damp and coal dust, of soda dynamite containing 40 per cent. to 45 per cent. soda crystals, have been obtained in Germany, and the subject is under experimental examination by Sir Frederick Abel.

The French Committee on Explosives have this year obtained favorable results in experiments at Sevran-Livry with mixtures of equal weights of dynamite and soda crystals, or sodium sulphate, or ammonia alum, or of ammonium chloride, none of which when detonated in an explosive gaseous mixture caused it to explode. They state that only those explosives the temperature of the products of detonation of which exceeds 2,200° C. (3,992° F.) are able to cause the explosion of fire damp. The temperature given on detonation by ordinary dynamite they state to be 2,940° C. (5,324° F.), by nitroglycerin 3,170° C. (5,738° F.), by gun cotton 2,636° C. (4,777° F.) Mallard and Le Chatelier (*Comptes Rendus*, cvii., pp. 96-99) obtained good results with a mixture of 20 per cent. of dynamite, or nitroglycerin, or gun cotton, with 80 per cent. ammonium nitrate ; the ammonium nitrate lowering the temperature, that of its detonation products being estimated at 1,130° C. (2,066° F.)

In concluding this part of my subject, it may be mentioned that to obtain safe explosives for coal blasting, Kubin and Siersch have patented the mixing of 20 to 50 per cent. of ammonium chloride or sulphate, or of both with dynamite, etc. (Eng. pat., March 10, 1888, No. 3,759) ; Kuhnt and Deissler, the mixing of 60 per cent. ammonium carbonate with 40 per cent. of dynamite (Eng. pat., April 21, 1888, No. 5,949) ; and that Schoneweg, with the same object, uses oxalic acid, or potassium, sodium, or ammonium oxalates, in an annular case external to the explosive, which may be his "*securite*," or other explosive.

Panclastite and Hellhoffite—Panclastite was patented by Mr. E. Turpin, in 1881 (Eng. pat., Oct. 18, 1888, No. 4,544), the subject matter of the specification being the manufacture and applications of hyponitric anhydride, or nitrogen tetroxide, NO_4. This was to be prepared by strongly heating lead nitrate—a method of preparation due to Gay-Lussac. When this salt is strongly heated, there is produced (as you will see) dark brown gas, consisting of nitrogen tetroxide and oxygen. The reaction is expressed thus :

$$Pb(N_2O_4)_2 = PbO + N_2O_4 + O.$$

(For the sake of simplicity I speak of the gas at higher and lower temperatures as N_2O_4.) The gas was to be condensed in enameled cast iron condensers, maintained at freezing point. The nitrogen tetroxide solidifies at —10° C. (+14° F.) (Deville and Troost), melts at —10° to —9° C. to a liquid, which at our ordinary room temperatures is of orange yellow color, boils at 22° C. (72° F.), and gives off at ordinary temperatures suffocating and irrespirable vapors.

Turpin (*loc. cit.*) proposed the preparation of an explosive which he called *panclastite* (of obvious etymology, from *πᾶν* and *κλάω*, *breaking everything*), by mixing carbon disulphide with nitrogen tetroxide, which are mutually soluble. He states that the maximum power is obtained from a mixture of equal quantities of the two constituents. Whether equal weights are intended, or equal volumes (when the weight relation would be 1 part by weight CS_2 and 1·14 parts by weight N_2O_4), the proportions recommended would be considerably deficient in oxygen even for the formation of carbon monoxide and sulphur dioxide, for : $4CS_2 + 5N_2O_4 = 4CO + 8SO_2 + 10\,N$; and if the reaction proceeded in that way, 1 lb. carbon disulphide would require 1·51 lb. of nitrogen tetroxide ; while for the higher oxidation $2CS_2 + 3N_2O_4 = 2CO_2 + 4SO_2 + 6N$, 1 lb. disulphide would require 1·82 lb. of N_2O_4. The mixture was to be detonated by fulminate of mercury or by a charge of fine gunpowder.

I have no personal experience of this preparation, but it is stated to be a powerful explosive.

Dr. Sprengel has pointed out (*loc. cit.*) that nitric anhydride, nitrogen tetroxide, and nitric acid head the list of oxidizing compounds, containing respectively 74·1 per cent., 69·6 per cent., 63·5 per cent. of oxygen available for the oxidation of other substances. Nitric anhydride is at present, however, only a chemical curiosity, and is difficult and costly to prepare ; so that of procurable compounds nitrogen tetroxide contains most available oxygen. It has the advantage also, as Berthelot has pointed out, of its formation being attended with scarcely any loss of energy ; its heat of formation being for the liquid state only + 1·7 kilogramme degree C. per 46 grammes (NO_2), while that of liquid nitric acid (from nitrogen, oxygen, and *water*) is higher, being + 7·1 kilogramme degrees C. per HNO_3 (which becomes + 7·8 heat units for the same quantity of available oxygen as in nitrogen tetroxide, and in addition there would be absorption of heat in gasifying the dead weight of combined water).

The use of this explosive for blasting in mines can hardly have been contemplated, as the presence of sulphurous acid in the gases would render the air unbreathable. Mr. Turpin has also proposed as explosives mixtures of nitrogen tetroxide with benzene, petroleum, and other substances.

Dr. Sprengel, writing in 1886, states that at that time nitrogen tetroxide was a commercial article, in price about eighteen pence per lb., and that it was sent about in France in tinned cans. (*Chemical News*, Feb. 26, 1886, p. 100.)

The use of these nitrogen tetroxide explosive mixtures appears, however, to be at present at a standstill.

Hellhoffite is one of Dr. Sprengel's nitric acid explosives, which was reintroduced by Hellhoff, of Berlin. It consists of 1 part by weight of dinitrobenzene and 1·5 part by weight nitric acid, or of 1 part nitrobenzene and 2·5 parts nitric acid; these are the calculated proportions for complete oxidation, viz.:

$$C_6H_4(NO_2)_2 = 6CO_2 + 2H_2O + 2N - 10O.$$

That is, dinitrobenzene is 95·24 per cent. deficient in oxygen for complete oxidation to carbon dioxide and water, and requires 1·5 times its weight of absolute nitric acid to supply the deficiency; and, similarly, nitrobenzene, $C_6H_5NO_2$, is 162·6 per cent. deficient in oxygen for complete combustion, and requires 2·56 times its weight of nitric acid. The dinitrobenzene is a crystalline solid; that most usually met with is called metadinitrobenzene, and is one of three dinitrobenzenes (it is the one obtained most abundantly on heating mononitrobenzene with mixed nitric and sulphuric acids) having the same percentage composition but different melting points, and other differences in their properties. The dinitrobenzene dissolves readily in the nitric acid, with considerable fall of temperature; the mononitrobenzene dissolves with considerable rise of temperature. In the former case there is the absorption of heat which would attend the solution of any solid in a liquid solvent which had no chemical action upon it; in the latter case there is rise of temperature, caused by chemical action. I should have mentioned that the nitric acid used is of 1·5 specific gravity (nearly absolute nitric acid). I shall be able to show the fall and rise of temperature in the respective cases, by means of this air thermometer arrangement, the air bulb being immersed in the nitric acid, to which we will add the dinitrobenzene in the first experiment, and, to an equal quantity, the mononitrobenzene in the second. The contraction and the expansion of the air in the bulb are made visible by the change of level in opposite directions of the colored indicating liquid.

Suitably primed, the dinitrobenzene nitric acid solution is a very powerful explosive. In experiments of Sir Frederick Abel's, in 1883, in which the solution mentioned was contained in a strong and closed iron vessel, which was buried in earth, and detonated electrically, effects were produced which approached (but were rather below) those produced by blasting gelatin under similar circumstances. It has been proposed for a special military use. For blasting in mines, there would be very serious inconveniences attending the use of nitrogen tetroxide or nitric acid explosive mixtures.

I have spoken of these explosives, using the names "panclastite" and "hellhoffite," under which they have been written about, and in connection with which you might desire information, but the invention of these explosives is due to Dr. Sprengel. Thus, in 1873, in his well-known and highly suggestive paper, "On a New Class of Explosives," etc. (*Journal Chemical Society*, 1873, pp. 796–808), he covers the general principle by his statement that a variety of organic substances dissolved in nitric acid of about 1·5 specific gravity explode by detonation. He experimented with the nitrobenzene mixture, and stated that it could be detonated with intense violence by the explosion in it of a fulminate of mercury detonator; and remarked that dinitrobenzene added to nitric acid would probably lower the temperature. He pointed out the high position of nitrogen tetroxide as an oxidizer, but as it was not then an article of commerce, turned to the use of nitric acid as the highest in value of procurable oxidizers.

Favier's Explosive, Bellite, Securite.—These three explosives may be conveniently mentioned together; they are a kind of Sprengel explosive, with ammonium nitrate taking the place of the nitric acid. A solid, non-corrosive product is thus produced. The available oxygen in ammonium nitrate is low, for here the base is combustible; the decomposition, $NH_4NO_3 = 2N + 2H_2O + O$, corresponds to an available 20 per cent. oxygen in the nitrate. Hence the quantities of ammonium nitrate have to be large, and a comparatively inert explosive (requiring a considerable amount of priming) is produced; for, although Berthelot shows that the decomposition equated above is accompanied by considerable evolution of heat, yet the particles of oxidizer and fuel are comparatively far apart compared with the constituent atoms of an explosive chemical compound, or with the molecules of an explosive solution like the so-called hellhoffite.

Favier's Explosive is of Belgian origin, patented by P. A. Favier (his French patent bears date July 21, 1883), and is said to consist of nitrates, mixed with paraffin, resin, or preferably nitronaphthalene. He recommends the following mixtures: 100 parts by weight ammonium nitrate, 5·75 parts paraffin, or 7·12 parts resin, or 9·02 parts nitronaphthalene; or 100 parts sodium nitrate, 9·26 parts paraffin, 13·40 parts resin, or 18·93 parts nitronaphthalene. The ingredients to be mixed and kneaded warm, and warm pressed; the cartridges to be coated with lac or resin by use of a suitable solution. It is stated that the explosive requires a priming of about 20 per cent. of dynamite, gun cotton, or similar substance, placed in a cavity in the pressed cartridge.

Bellite was introduced by C. Lamm, of Stockholm, and patented in this country in 1885 (Eng. pat. Nov. 10, 1885, No. 13,690). He proposed to mix a nitrate with an aromatic nitro-compound (such as dinitrobenzene, trinitronaphthalene, or nitrotoluene), the mixing being effected in a drum heated by steam from 50° to 100° C. (122° to 212° F.), the nitro-compound melting and coating the particles of nitrate, cartridges being pressed while the mixture is warm. It may be noticed that, according to recent descriptions, the three trinitronaphthalenes which have been obtained all melt above 100° C. The dinitrobenzene usually obtained (the *meta*-modification), when pure, melts at 89° C. (192° F.), the commercial article at about 86° C. (187° F.) Here is some of it; we shall see that it readily melts in a test tube placed in nearly boiling water.

Mr. Lamm, in the specification referred to, recommended the use of mixtures of potassium nitrate with dinitrobenzene, or with trinitronaphthalene, in such proportion as to oxidize the carbon to carbon monoxide; or, if considered advisable, the amount of nitrate might be increased to the proportion required for complete oxidation.

Bellite is stated by the *Revue d'Artillerie* (of May, 1887) to produce its maximum effect when consisting of 15 per cent. dinitrobenzene and 85 per cent. ammonium nitrate (which is more nitrate than is required for complete combustion). Some trials of bellite have been quite recently (November, 1888) made in ironstone mines in the Cleveland district, and results obtained favorable to the use of bellite for blasting some kinds of mineral. The bellite used is said to have consisted of one part of dinitrobenzene and five parts of ammonium nitrate (this is about the proportion—1 : 4·76—for total combustion to CO_2 and H_2O). From the experiments described (*Engineering*, Nov. 9, 1888, p. 462), bellite seems capable of doing a large amount of total work, its action extending over a wide range, but its rate of detonation would seem to be comparatively slow. There are, of course, applications for which this comparative slowness would be valuable.

I have gone into some detail about bellite, because it may be taken as a type of these nitrate of ammonia explosives, and there is more experimental detail to hand about it than about some of the others.

I cannot do more than mention the very similar *securite*, patented by H. Schoneweg (Eng. pat., May 18, 1886, No. 6,664). His proposal to use oxalic acid, or oxalates, in combination with *securite*, or other explosives, to obtain an explosive said to be flameless, has already been mentioned.

I must mention the remaining explosives rather hurriedly, and with less detail than I should have wished, and first: *Roburite*, which was patented in 1886, by Dr. E. Roth (German pat., D.R.P., No. 30,511, April 20, 1886. Eng. pat., provisional specification, July 14, 1886, No. 9,766; complete specification, Feb. 21, 1887, No. 2,679), and which has this interesting point of difference from the explosives just mentioned, that *chlorinated* nitro-derivatives of aromatic hydrocarbons, or phenols, are employed in admixture with a nitrate. In his provisional specification, Roth states that he has proved, by numerous experiments, that (in roburite) the dynamic effect is considerably increased by the use of *chloro*-nitro compounds, probably (he states) in consequence of the increase in the volume of gas produced. He gives six examples of the commercial preparation of these chloro-nitro compounds, and states (in effect) that they are to be mixed, according to the carbon and hydrogen present, with about 2 to 3·5 parts of a nitrate, the mixture to be detonated by means of fulminate of mercury.

The roburite actually in use is, I believe, a mixture of chlorinted dinitrobenzene with ammonium nitrate. From the accounts given of the use of roburite, there appears to be a useful field for it in coal blasting, for which application the claim of safety is made.

Romite (the name probably from '*ῥώμη, strength*) is an explosive patented by R. Sjoberg, of Stockholm (Eng. pat. Jan. 11, 1887, No. 448, and Aug. 27, 1887, No. 11,658); and, in the latter specification, stated to be prepared from ammonium nitrate, which is mixed with a solid, melted hydrocarbon (naphthalene, paraffin, and the like), and gelatinized by paraffin oil, together with pure or similarly gelatinized potassium chlorate, for which latter salt a crude nitrolactin (nitro milk sugar) may be substituted. In actual practice, I believe that romite consists of ammonium nitrate, naphthalene or nitronaphthalene, and paraffin oil; to be mixed with potassium chlorate or with nitrolactin at the place where it is to be used.

Kinetite (the name no doubt from *κινέω*, "*I move*") was patented by T. Petrey and O. Fallenstein (their English patent is No. 10,936, August 6, 1884). As described in their specification, kinetite is made by dissolving gun cotton in nitrobenzene, or other liquid benzene or benzenoid nitro compound; the jelly thus formed is mixed, by kneading, with finely powdered potassium chlorate or nitrate (or other metallic chlorate and nitrate), sulphur in the free state, or as sulphide, is added, and the whole well kneaded. The proportions proposed were 16 to 21 per cent. of the aromatic nitro-compound, ¾ to 1 per cent. of gun cotton or other form of nitrocellulose (these two constituents forming a 5 per cent. gun cotton jelly), 82¼ per cent. to 75 per cent. of alkaline chlorates and nitrates, 1 per cent. to 3 per cent. of sulphur as antimony pentasulphide.

In actual use, I believe, the proportion of potassium nitrate to chlorate is small. Subsequently, at least in the kinetite for use in this country, the pentasulphide of antimony was omitted for the sake of increased safety. Dr. Dupre found it to be too sensitive to concussion, and I believe I am correct in stating that it has not up to the present been licensed in this country. From the statements made about it, kinetite appears to need for its use a powerful detonator and confinement.

The solvent action of nitrobenzene toward gun cotton, even in the cold, is remarkable. Here is a 5 per cent. gun cotton jelly, the gun cotton was added as yarn to the nitrobenzene about an hour since. The former too is mainly trinitrocotton.

Rackarock is one of Dr. Sprengel's potassium chlorate explosives, described in 1873 in his paper, to which I have frequently referred. It received the name of rackarock in the United States, where it was used in 1885 for the blasting of Flood Rock, Hellgate, which had always been a source of danger to vessels entering New York Harbor. It consists of a nitrobenzene absorbed in, or mixed with, powdered potassium chlorate. Nitrobenzene requires additional oxygen to the amount of 162·6 per cent. of its weight to be supplied to it for its complete combustion to CO_2 and H_2O; the following equation for its complete combustion by potassium chlorate, $6C_6H_5NO_2 + 25KClO_3 = 36CO_2 + 15H_2O + 6N + 25KCl$, requires a mixture of the chlorate and nitrobenzene containing 19·4 per cent. of the latter.

General Abbot (United States Engineers) experimented with a number of mixtures with varying proportions of the two constituents; they were hand mixed, and detonated under water, the charges being loosely compacted in tin cans. The intensity of action of the mixtures was found by the compression of the lead "crushers" of his well known "ring apparatus;" the greatest effect was produced by the mixture of 21 per cent. nitrobenzene with 79 per cent. potassium chlorate. This is a close approach to the calculated proportion (19·4 per cent.) just given. The intensity of action of rackarock (the 21 per cent. mixture) detonated under water in a thin case (a tin can) General Abbot found to be about 108; kieselghur dynamite No. 1 (containing 75 per cent. of nitroglycerin) being = 100. (General Abbot, Addendum III. to his Report.) For the blasting of Flood Rock, 107 tons of rackarock and 300 tons of dynamite were employed. The rackarock was used in 6 lb. cartridges, into each of which a priming cartridge was inserted; in the dynamite cartridge was a thin copper shell, containing fulminate of mercury. The rackarock cartridges were not fired electrically, but by the shock (or by the "sympathetic explosion") of separate electrically fired dynamite cartridges. Time fails me to give more details of this interesting operation, which was most successfully carried out by the United States Corps of Engineers on October 10, 1885. Rackarock has also been used in another important civil engineering work, the making of the Vosburg Tunnel, in Pennsylvania. The tunnel, which is a long one (3,902 feet long), was commenced in 1883 and finished in 1886; rackarock was used in the headings and Atlas powder for the remaining portion of the work.

Mr. W. D. Borland proposes to add about 5 per cent. of his cork charcoal to this explosive. He claims that it makes the mixture plastic, and increases the rapidity of detonation. (See his carbos-dynamite specification.)

Picric Acid.—The fact that picric acid may be detonated by means of fulminate of mercury was first recorded by Dr. Sprengel in 1873 (see his paper of that year, "Journal of the Chemical Society," p. 803). He remarks that it is a powerful explosive when fired by a detonator.

The use of picric acid (without any admixture of oxidizer) has been patented by E. Turpin (Eng. pat., 1885, Dec. 8, No. 15,089), its use in the fused state, or agglomerated by collodion and moulded, being especially recommended. He proposes the use of a detonator containing 1·5 gramme (about 23 grains) of fulminate of mercury as answering well for picric acid in dry powder, but for cast or agglomerated picric acid uses an intermediate priming of picric acid in powder.

Picric acid is a powerful explosive, and the high specific gravity of the cast acid (1·6 to 1·7) gives it an advantage when comparison has to be made *by volume*.

Commercial picric acid melts at about 119° C. (246° F.) Here is a small quantity (an ounce or two) melted by means of a suitable bath of liquid. In the melted state the acid is a yellow liquid. We will make a cylinder of it by pouring it into this mould.

The acid heated by itself burns with a smoky flame. It has long been known that potassium picrate, lead picrate, and other picrates would detonate on heating. Dr. Dupre made the interesting observation that a mixture of two parts by weight litharge (oxide of lead) with one part picric acid detonates violently when heated. I will heat one grain of this mixture on this piece of tin plate, and this quantity will be sufficient to give a very sharp explosion. The very serious explosion which occurred at Messrs. Roberts, Dale & Co.'s works at Cornbrook, near Manchester, was considered by Colonel Majendie to have been caused by the detonation of such a litharge and picric acid mixture, made by the flowing of the melted acid into the litharge present in the same room. For details of experiments conducted for the home office by Dr. Dupre and Colonel Majendie, in association with Sir Frederick Abel, I must refer to Colonel Majendie's report, dated Aug. 15, 1887.

I will conclude with the mention of *ammonio-nitrate of copper*, $4NH_3$, $Cu(NO_3)_2$, which has been proposed and patented, as an explosive, by Mr. A. Nobel (Eng. pat., Dec. 8, 1887, No. 16,920). He states that, while this chemical compound has long been known, it has never been understood to possess explosive properties, but he finds that it can be exploded by a fulminate detonator, and that it is capable of exercising very great power, and gives a very short flame of comparatively low temperature. The explosion must result from the oxidation of NH by the nitrate of copper. The H and O are in the proportion for complete combustion.

I may mention, however, that it is on record that the ammonio-nitrate and the double nitrate of copper and ammonium ($Cu(NO_3)_2 \cdot 2NH_4NO_3$) explode when heated.

DISCUSSION.

The chairman said the subject treated in this paper was a vast one, and, in fact, in no branch of science had greater strides been made, within a comparatively small number of years. For fifteen years after gun cotton and nitroglycerin were discovered by Schonbein and by Sobrero, very little use was made of those substances, and not until scientific investigation was brought to bear on their behaviour as explosives did their practical application develop. Since, however, we learned how to use these materials in various forms, other important chemical compounds had come into practical use, the employment of which a few years ago was scarcely dreamed of. Substances which, in some instances, were nothing more than chemical curiosities, were now in extensive use. Some of these were applied to important industrial purposes, quite distinct from their properties as explosives. For example, picric acid had been long used as an important coloring matter. In some instances such materials were already used on a large scale as explosives; in others, only to such an extent as to give promise for the future.

Mr. Reid asked what was the particular advantage which had been derived from Von Forster's method of waterproofing gun cotton. It was perfectly capable of being detonated in the wet state, and, therefore, he did not see the advantage of waterproofing it.

Mr. Deering said he was not aware of any advantage, and he understood that Von Forster had himself returned to the method of coating primers with paraffin, only gelatinizing the hole for the detonator with acetic ether. He had mentioned several things in the paper without intending to recommend them, but simply as matters on which information might be desired, and this was one of the most striking propositions which had been made with regard to gun cotton.

Mr. Bloxam asked if any information could be given with regard to smokeless powder.

Mr. Deering said he had not touched on the subject for more than one reason. It was rather a delicate subject to deal with, being still under consideration and experiment, and he had quite as much matter as he could deal with apart from it. Most smokeless powders were either gun cotton treated in some particular way or some form of nitrocellulose.

Mr. Price Edwards said he had hoped to obtain some information on one or two practical points, particularly as to the best kind of explosive to use for particular descriptions of work. He had not been able to find any definite statement as to the relative strengths of different materials, nor how they could be measured, which information would be very useful to many persons. He should also be glad to know if there were any explosives which were specially safe when stored; he knew that some were very dangerous to keep and

manipulate, while others were much safer to handle. Another very important point was as to the use of explosives under water. He had been told that the best or one of the best ways was to put the explosive in India rubber bags, and he should be glad of any information on that point. It was often used in this way for the purpose of destroying wrecks or submarine obstructions, and in such cases it was often desirable to have a substance which would produce its maximum effect in a downward direction, but he believed this was often produced by the superincumbent weight of water. Lastly, he would say that as explosives were often required for making fog signals, it was desirable to know which was the best for that purpose, and the one which would produce the most intense sound wave.

Mr. Deering said he had referred in his paper to the use of a massive lead cylinder, by the detonation of explosives in which Sir Frederick and others had gained very valuable information as to the comparative intensity of action of different explosives. With regard to the use of explosives under water, General Abbot's well-known work on the use of explosives for harbor defense contained a table showing the energy exerted by different materials used in 35 lb. charges, as measured by the compression of small lead cylinders. The method of measuring the intensity of the force must depend on the work in hand. For rock blasting, if the seams were pretty homogeneous, one would measure the cubic yards of rock blasted per unit of weight of the explosive used.

Damp gun cotton was probably the safest explosive of any; it could be stored in the wet state, and could be detonated at any time by a dry primer. An India rubber bag would answer very well for use under water with a sharp explosive in superficial contact with the timbers of a wreck. General Abbot's tables showed that the intensity was rather greater, in most cases, in a vertical direction upward, and was less than either horizontally or downward. As a good material for sound signals, there was gun cotton and tonite; he should think for such purpose the sharper the rate of detonation, the better. He did not think there was anything purchasable better than gun cotton, or preparations of it, which would include tonite.

The chairman said he would add a word or two to supplement Mr. Deering's reply to Mr. Price Edwards. The application of explosives to fog signals was made the subject of a very careful inquiry by the Trinity House, with Dr. Tyndall as *collaborateur*, and a very large number of experiments was carried on with gunpowder used in various ways and with gun cotton in various forms. As the broad result of these experiments, it was found that preparations of gun cotton, such as nitrated gun cotton, or tonite and potentite, gave the best penetrating sound, capable of being transmitted to considerable distances, even under somewhat unfavorable conditions. The fog signals now generally used were made of either compressed or nitrated gun cotton. India rubber bags had been largely used for some time past by the Royal Engineers in submarine operations, and had proved thoroughly efficient. There was no difficulty in getting them to withstand the water pressure, and in applying them very readily so as to bring the explosive agent into as advantageous a position as possible for action at considerable depths. There were many topics in the paper which had been scarcely touched upon, which would have furnished matter for interesting discussion, and one could but regret that so short a time could be given to so interesting a subject.

The question of smokeless powders, for example, had not been at all dealt with. He might observe that the new sporting powders which were so well known were the parents of many of the smokeless powders which had been brought out of late years. Such powders were now no longer a secret, for patents had been published with regard to them. The great difficulty was to manufacture them by simple processes on a large scale, so as to secure the uniform attainment of high velocities and at the same time the development of only moderate pressures. Many men of great ability were working at this subject, and he had no doubt that for many purposes, for small arms especially, there would be before long comparatively smokeless powders, upon which perfect reliance could be placed, both with regard to stability and to certainty and uniformity of action.

THE REMOVAL OF ROOF WATER FROM BUILDINGS.

By DWIGHT PORTER, Ph.B.

IN most cases roof water will soon take itself off without assistance, but its manner of doing this, and the final disposal thus made of the water, are not always satisfactory. Dripping eaves projecting over city sidewalks would be an intolerable nuisance: and whether in city or in country, rain water allowed to fall freely from the roof to the ground next the building tends to dampen the cellar, foundations, and walls, and thereby to injure the health of inmates of the building, as well as to harm the structure itself and property contained within. It therefore becomes essential to direct the course of water falling upon the roof, and to convey it away to a proper point of discharge. To effect these purposes various arrangements have been employed, some of which will be mentioned.

For directing the course of the water, as it is received upon the roof, to a suitable point of discharge, we have gutters. On old-fashioned country houses these were often made from a log of moderate diameter, sawed lengthwise, gouged out, and supported by hooks or brackets under the eaves. In modern construction the gutter is very commonly made angular in cross section, formed upon a wooden cornice, with a protecting sheathing of tin, galvanized iron, or copper. Half round or angular gutters of these metals are also used hung at the eaves.

Galvanized Iron Gutters

Leaders, conductors, or rain spouts, as they are variously termed, receive the discharge from the gutters, and, descending toward the ground, convey the water a stage farther in its journey. The problems connected with rain leaders are not very intricate, but yet they have not always been well solved. It is not a difficult matter to arrange a few leaders for receiving the roof water of a building; but from mistaken economy, or from lack of knowledge or of forethought in the matter, they often prove inefficient when most needed, and are a constant source of trouble and expense.

Their size, which is commonly determined by experience and judgment, and not by calculation, ranges in diameter from two to six inches. Two-inch pipes are too small to serve to advantage as main leaders on almost any building, being easily choked. Three-inch and four-inch pipes are suitable and common sizes for ordinary dwellings and small commercial buildings. The five-inch and six-inch sizes find employment on large structures.

The Produce Exchange building, in New York City, with a roof area of three-quarters of an acre, roughly speaking, has twelve leaders, of about five inches diameter. The roof, which is paved with fire bricks, is graded with slopes of perhaps 1 in 50 toward the points at which the leader openings are placed, most of these draining surfaces of about 40 × 70 feet each. The provision here made is equivalent to about one square inch of leader opening to 140 square feet of roof surface. On the Sloane building, at Nineteenth Street and Broadway, with a roof area of 18,000 or 20,000 square feet sloping 1 in 25, there are two leaders of about six inches diameter and a third rectangular, four inches by six inches. This gives an allowance of 240 square feet of surface to the square inch of leader opening, while on the Massachusetts Hospital Life Insurance Co.'s building, and the Hemenway building, in Boston, the proportion is only from 60 to 70 square feet to the square inch of opening.

	Approximate Roof Surface.	Approximate Surface per sq. in. of Leader Opening.	
Produce Exchange building, New York.	33,000 sq. ft.	140 sq. ft.	Twelve 5" leaders.
Sloane building, New York.....	19,000 "	240 "	Two 6" leaders, and one 4" × 6".
Mass. Hospital Ins. Co. building, Boston....	6,000 "	70 "	Seven 4" leaders.
Hemenway building, Boston.....	4,000 "	60 "	Five 4" leaders.

Whether a roof slope steeply or gently, there is a certain amount of water falling per second or per minute in storms, which must be removed; but I have learned of no generally recognized rule among architects as to the leader provision which should be made for it.

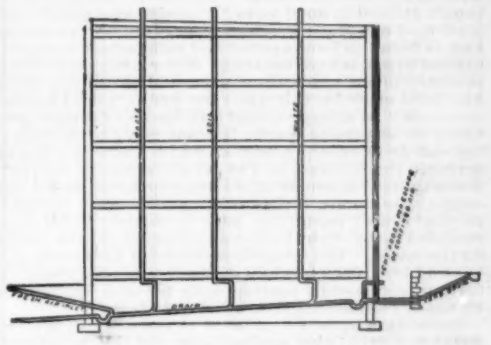
A vertical rain leader does not, of course, run full bore, even in the hardest storms, and yet, if carried down from the roof with its course unbroken by sharp bends, and if given a suitable opening at the top, there is probably little danger of its proving inadequate. It is very common, however, to introduce abrupt changes of direction to suit peculiarities of architecture, by which the carrying capacity of the pipe is curtailed, and the liability of choking by leaves, rubbish, and ice is greatly increased. On a business block on Sudbury Street, in Boston, may be seen a rain leader which within a few feet of the point of leaving the gutter makes four abrupt and nearly right-angled changes of direction. It will frequently be noticed on buildings, also, that the immediate connection between the gutter and a four-inch leader of ample capacity is effected by a very much smaller pipe of lead.

In connection with important buildings there is perhaps more need of caution in designing the drain of suitable size than in fixing upon the size of leaders. Formerly house drains were made entirely too large—an error which has come to be recognized, and has led to the practice of using comparatively small sizes. These are advantageous for procuring an effective scour of the pipes by the slight flow of ordinary house drainage, but have in numerous instances proved practically insufficient for managing the volume of water furnished by heavy storms, which is doubtless often hundreds of times as great as that coming from interior house drainage. In the Sloane building, to which reference has already been made, I am informed that it was found necessary, on this account, to enlarge the main drain from 8 inches diameter to 10 inches, considerable damage having been suffered, two or three summers ago, from a flood of rain water during a severe storm.

A practical difficulty connected with the delivery of roof water to the house drain has also been experienced under certain circumstances, in the apparent carrying along by friction, and imprisonment, of a large amount of air by the descending column of water, and a consequent pressure upon the traps of connecting pipes, and even a serious interference with the flow in the main drain itself, unless relieved by ample venting. An instance was mentioned to the writer by Mr. John C. Collins, Chief Inspector of Plumbing for the New York Board of Health, in which very considerable injury to property resulted in this way, the rain water bursting out near the bottom of a leader and flooding the basement of a building. The leader ran down the rear of the building, the main part of galvanized iron, succeeded near the bottom by a cast iron shoe connecting with the drain. In the drain was a running trap near the foot of the leader, and another near the front of the building. Two stacks of waste pipe and a stack of soil pipe joined the drain between the traps, and there was near the front of the building the usual four-inch fresh air inlet. Still, the five-inch drain appeared incapable of serving the leader in heavy rains, and water would back up 10 or 12 feet high in the leader and overflow at the top of the cast iron shoe. That the trouble was due to the interference of imprisoned air was indicated by the fact that it was partly relieved by inserting a two-inch air vent between the leader and the first trap, and entirely overcome by a three-inch vent.

Now and then we find the roof water carried to the street sewer in an independent line of pipe, but the usual, and what is generally considered the preferable, practice is to conduct it directly into the house drain, sometimes at the back end, sometimes at the front, just inside the main trap, and again at both these or at intermediate points, according to circumstances.

On a large proportion of city buildings the rain leaders run down the outside of the walls, but yet in a considerable number they are carried down within the walls, in which case it is evidently desirable that the same care should be taken to prevent the escape of drain or sewer air through defective material and joints that would be taken with stacks of soil or waste pipe. Consequently we find in the public regulations in force in large cities requirements that the leaders shall be constructed of iron (in New York copper may also be used), if carried within the walls. In New York City it is permitted that leaders of iron or copper shall be without traps, unless the top is near a window, in which case a trap is required at the base. In Boston, however, all leaders must be trapped in new construction.



The troubles encountered in the practical service of leaders and gutters are occasioned in part by their becoming choked with leaves or rubbish, but principally by their being clogged and burst by accumulations of ice in winter. Leaves and rubbish may be largely excluded from leaders by the use of wire strainers or iron gratings, though these of course do not prevent accumulations outside and near the tops of the leaders. In the midst of a large city, however, leaves are usually strangers, and in a cold climate the trouble with gutters and leaders comes from ice. It is very common to see a tin or a galvanized iron leader brought from the roof down the face of a building and terminating in an iron "pipe shoe," as it is called. Such an arrangement will be found on the brick blocks of tenement houses on Nashua and Billerica streets, for example, in Boston, and walking through these streets it will be noticed that nearly every one of the cast iron shoes has been split by ice. Leaders often become incased in ice to the size of a barrel, from top to bottom, while from gutters and eaves depend huge icicles which threaten the heads of passers below.

These troubles from ice cannot in all cases be conveniently and entirely avoided, but on important buildings it is perfectly practicable to escape them by proper location of leaders and gutters, by the use of pipes of suitable material and shape, and by the supplementary employment, in some cases, of steam.

On steeply pitched roofs, gutters are naturally found at the eaves, either built out or suspended, as has before been mentioned, with leaders running down on the face of the walls. But large business blocks are now very commonly built with tolerably flat roofs, a long slope from front to rear being succeeded by a short rise to the edge of the roof, the V-shaped channel between the two slopes serving as an ample gutter. Sometimes, indeed, as on the Morse and the Wilde estate buildings, on Washington Street, in Boston, the roof is given a slope from both front and rear toward the center, where the gutter channel is thus formed. In either of these constructions, the gutter being entirely upon the main part of the roof, it is natural and easy to carry down the leader within the building, and where this is done, little or no difficulty is experienced from ice. Rain, snow, and ice then take care of themselves, and the heat of the building, supposing it to be occupied, is found sufficient in this climate to prevent accumulations within the leader.

As has already been said, the regulations in large cities would prescribe for such cases iron or copper pipes, which indeed would naturally be employed. The same materials may be, and often are, utilized also for outside leaders, but galvanized iron and tin are far more common. The choice of material is important chiefly in connection with the lasting qualities of the pipe; the shape of the cross section, and the mode of making the longitudinal seam, are important as regards protection against bursting by ice.

In some parts of the country zinc was once almost exclusively employed for leaders; in other parts, tin. Tin pipes are still perhaps the most commonly used, on the whole, of all kinds, on account of cheapness in first cost; but galvanized iron pipes are considered superior, and being not greatly more expensive than tin are given the preference in good work. Either material, however, is subject to gradual corrosion from the water which comes in contact with it, more rapid corrosion from the moist salt air along the coast, and still more rapid corrosion from steam and from sewer air. In New York City, for instance, there are many leaders having untrapped connection with drain or sewer, and these leaders, whether of tin or of galvanized iron, are said to withstand corrosion generally but a very few years.

There are two principal varieties of tin in use for roofing and leader purposes. The old fashioned or bright tin is "black iron," as it is called, or more and more commonly at the present time a mild steel, covered with a coating of pure tin. The dull tin, which is now largely made, has the coating of tin with an admixture of lead. The bright tin, which alone of these varieties is safe for culinary articles, and which is often also supposed to be best suited to use on buildings, is considered by many whose experience is of value to be inferior for this purpose to a good dull or "leaded" tin. The latter material, when redipped in the process of coating, resists corrosion from moist and especially from salt air much better than the former.

The so-called galvanized iron is either black sheet iron covered directly with a coating consisting chiefly of zinc, or it is sheet tin so covered, the iron having in this case a double coating.

Far superior to either tin or galvanized iron is copper, which is practically unaffected by the ordinary agents producing corrosion of roof coverings and leaders. It has been very considerably employed in first class work, but its cost is at present a serious bar to extensive use. Galvanized iron leaders cost perhaps 20 per cent. more than tin leaders of the same size. Two or three years ago, before the rise in copper, leaders of the latter material cost approximately half as much again as those of galvanized iron, but I am informed that they now (September, 1888) cost about two and one-third times as much as the galvanized iron.

Copper leaders are made of all shapes and sizes used for other materials. Hot rolled copper was the variety formerly employed on buildings, but prejudice was aroused against it because of its softness and the ease with which it loses its shape. Cold rolled copper, which is now utilized in good work, is harder and stiffer, and if selected of a grade weighing 18 or 20 ounces per square foot, is found to be a superior and satisfactory material. Copper expands and contracts under changes of temperature much more than iron, and allowance often has to be made for this when the metal is used in construction. In a long vertical rain leader of copper provision for change of length is often made by introducing one or more slip joints, at which there is a lap of perhaps three inches, and at which solder is omitted. The slip joint of course offers some opportunity for the escape of sewer air, if that is allowed to enter the leader; but if well made, the joint is claimed to be soon rendered fairly tight by a slight coating which forms on the metal. The protection afforded to tin and galvanized iron pipes by their distinctive coatings may be further increased by coating with tar and asphalt, or by use of the adamanta or other coverings.

But while a suitable material is essential to the endurance of the pipe against corrosion, its protection against bursting by ice is to be obtained partly by the mode of joining the material, but chiefly by the shape given the pipe in cross section. The common tin pipe is made in short lengths soldered together at the transverse joints, each length having a straight longitudinal seam, which is either a soldered lap joint or a simple locked joint. The lap joint is not so strong as the rest of the pipe, and under the great expansive pressure of ice is opened. Whatever, then, tends to strengthen the longitudinal jointing of the pipe gives greater resistance against moderate ice pressure, although no plain pipe of ordinary thickness is proof against rupture by ice. The locked joint is an improvement upon the plain soldered lap joint, and is used for galvanized iron and copper as well as for tin. The plain lap joint can be strengthened by riveting, and I have seen copper leaders made with a straight soldered and riveted seam, which is claimed to be stronger than the main body of the pipe, the latter yielding first to ice. Galvanized iron leaders are also made with a patented spiral and riveted seam, which renders them very strong.

Economy of material for a given cross-section of pipe demands the use of a plain circular form; but it is evident that no shape would be more unyielding against the expansive power of ice, and in order to accommodate the latter and prevent rupture, the expedient of a fluted or corrugated pipe was hit upon some fifteen or twenty years ago, and patented. This form of pipe has been very extensively used, and appears to have been generally satisfactory in resisting ice, readily changing its shape under pressure. Tin, galvanized iron, and copper pipes are all to be had of the corrugated form, being usually circular in general shape, but often made rectangular as being more ornamental. A good corrugated copper pipe would appear, all things considered, to be the best available construction. The patent upon corrugated pipes expired a year or two since, and they are now manufactured by a number of competing firms.

Even if a leader pipe be used which will not be ruptured, it is, if exposed, liable to become so choked with ice as to be unable to carry off water, and the same thing also happens in the case of gutters. Hence in a climate as cold as that of Boston, resort is frequently had to the use of steam, not so much, however, for the purpose of preventing the formation of ice in freezing weather as to clear a passage for the water when a thaw comes on. Most large buildings at the present time have a supply of steam, either for heating or for power, which can without much difficulty be drawn upon during the day time for use in the way that has been mentioned.

The most common method of using steam for thawing out leaders is to introduce a small jet from perhaps a ⅜ inch or a ½ inch pipe at the base, and allow the steam to rise up through the leader. This plan is followed at the Wakefield building, on Canal Street, in Boston; and as a precaution steam is thus at times introduced also into the base of an iron leader in the Wilde estate building. At the Sloane building, in New York, the same plan has been successfully tried, but has been practically superseded by allowing hot water to drip into the tops of the leaders. Waste steam from the heating and elevator systems passes into small drum-shaped condensers on the roof, and the hot water of condensation is conducted through drip pipes to the leaders. The climate of New York City is so much milder than that of Boston that comparatively little trouble from ice is experienced; and the common practice of an untrapped connection with drains and sewers, the air of which is warm, tends to prevent serious accumulations within the leaders.

Another method which is sometimes, but less commonly, used is to carry up a steam pipe through the interior of the leader. At the Cheney building, in Hartford, Conn., a ¾ inch steam pipe is thus employed. This pipe has an iron cap a foot or so above the roof, the cap being perforated by a small hole to permit some circulation of steam, but the hole quickly becomes stopped by rust. The condensation of steam within the pipe, and the freezing of the water thus formed, has split the pipe at various points; but the steam escapes all the more readily in consequence, and the arrangement is entirely successful in clearing out the leaders.

Even if the leaders are kept open, the gutters are very likely to become clogged with ice, and then fail to perform their duty. Attempts have therefore been made to clear these also by the aid of steam, and on the Studio and Museum buildings in Boston may be seen arrangements of steam pipes for this purpose. The gutters are of the common half round metallic type, projecting out from the edge of the roof, the steam pipes extending along over the center of the gutters and about on a level with the top. On the Studio building the pipes are pierced beneath with small holes at intervals of say six inches, with the object of directing downward into the ice of the gutter a great many small jets of steam. This device is not satisfactory, however. A hole is melted in the ice by each jet, but ridges are left between the adjacent holes that have to be chopped away. Water also enters from the gutter into the steam pipe, freezes there, and bursts the pipe.

It seems probable that if steam pipes are to be used in gutters, they should either be arranged with jets closer together than in the case just mentioned, and perhaps directed obliquely into the gutter; or they should be tight pipes laid on the bottom of the gutters, with a circulation of steam assured by an opening at the end or by a properly arranged return pipe, and with sufficient grade so that the water of condensation may readily flow off.

On the Wakefield building, and to some extent on the Studio building, steam is brought on to the roof from the nearest convenient point in a hose, and in that way directed at will upon the ice in the gutters. In the latter building the steam employed is that used for heating, is at a pressure of six or eight pounds only, and is found not very efficient in cutting out the ice; but on the Wakefield building the steam is that used for power, is delivered under a pressure of fifty or seventy-five pounds, and is considered very satisfactory in clearing the gutters.

In conclusion, it may be said that in the case of large buildings, at least, it is possible, by some of the methods that have been pointed out, to avoid all inconvenience from roof water, from whatever source; and on private dwellings, if the water is brought down from the roof in a vertical and unbroken descent, and a good corrugated pipe is used, there will be but little trouble.

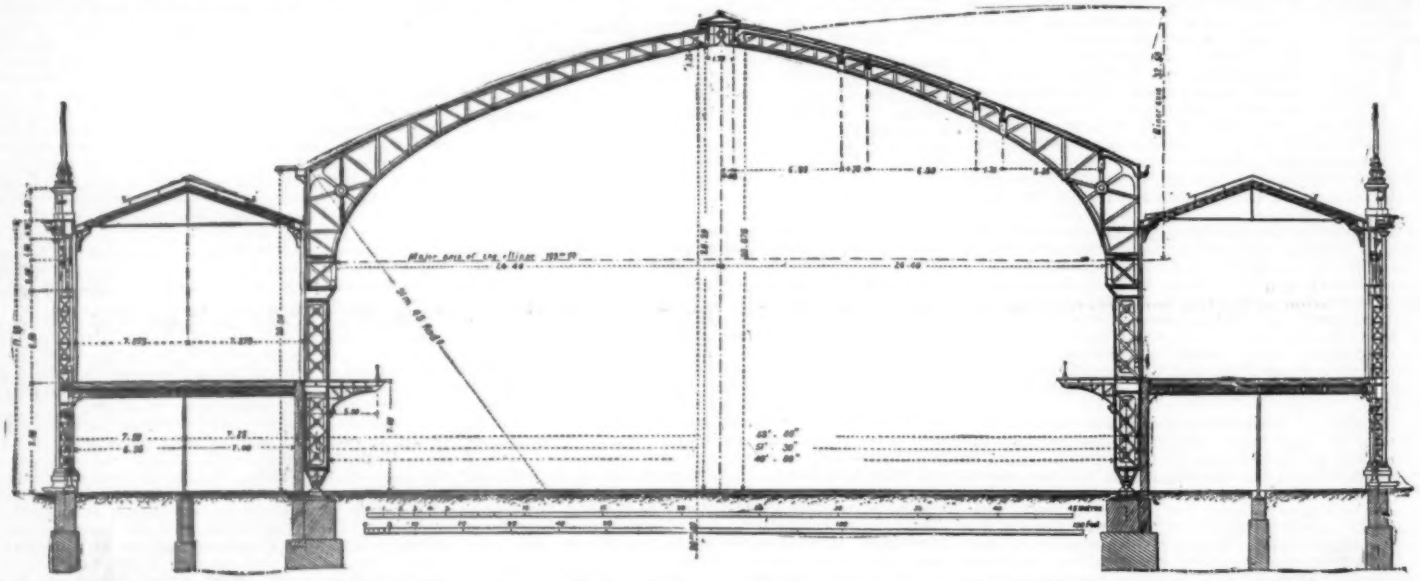
In most cities the destination of the water, whether it be directly discharged into the house drain or into the street gutter, must quickly be the public sewers. To what extent, if at all, this water shall be excluded from the sewers which convey the other house drainage, is a question of importance in certain cities, but its discussion need not be entered upon here.—*Technology Quarterly.*

THE FINE ARTS AND LIBERAL ARTS GALLERIES, PARIS EXHIBITION.

THE Fine Arts and Liberal Arts Galleries, which form a conspicuous feature in the Paris exhibition of 1889, are symmetrically situated on each side of the major axis of the Champ de Mars and the central garden. They adjoin the avenues which bound two sides of the inclosure; the former being near the Avenue de Labourdonnais, and the latter near the Avenue de Suffren.

These galleries are constructed almost alike, except for some modifications of detail. They each comprise a grand central nave bordered laterally by low aisles, similar to the Machinery Hall. There is at the center of the nave a dome 60 meters (197 ft.) in height, covering an area of 2,500 square meters (26,910 square feet). The central nave is 103 meters long, and is framed with eight principals, having a span of 52·8 meters (173 ft. 3 in.), a height of 28·2 meters (92 ft. 6 in.), and a pitch of 18·1 meters (59 ft. 10 in.), except at the ends, where the distance apart is 6·25 meters (20 ft. 6 in.) The distance between the principals is divided into four equal parts by three longitudinals connected together by purlins. Upon the principals and the longitudinals rest the rafters, on which are mounted the frames for the skylights. The galleries, which run parallel to the axis of the hall, are 15 meters (49 ft.) wide. At the end next the Seine the gallery is also 15 meters wide; it runs the whole width of the building.

At the opposite end there is a gallery of 30 meters (98 ft. 5 in.) opening, connecting each of the two halls with the galleries of *Industries Diverses*. The length of these two galleries is equal to the width of each hall. They serve as entrances to the exhibition from the Avenue de Labourdonnais and the Avenue de Suffren, and they occupy the site of the avenue which traverses the Champ de Mars, and bear the names of the Rapp and Desaix Galleries. Each roof principal, of a length of 52·8 meters, is composed of two similar frames spaced 18 in. apart, each having its own bracing, the two frames being connected together to form a light and rigid structure. The frames are articulated at three points, at the springings and the apex, in order to fix definitely the exact points through which the



THE PARIS INTERNATIONAL EXHIBITION OF 1889—FINE ARTS AND LIBERAL ARTS GALLERIES.

strains pass. At each joint there is only one pin for the two half frames, the pin being fixed in two cast iron bearings attached to the parts which are to be united. Each frame is formed with a vertical portion 15 meters (49 ft.) high, followed by a curved beam, the extrados of which is an arc of a circle of 91·45 meters (300 ft.) radius.

The intrados is elliptical, but as the minor axis of the ellipse does not coincide with the arc of the frames, there results at the ridge an angle formed by the two intrados of the two half frames. At each side of the top joint, and at 2 ft. 10 in. from the axis, there is a purlin which supports a ridge path for the use of workmen. The other purlins are disposed at the sides, as indicated above, in groups of two spaced 1·7 meters (5 ft. 7 in.) apart. The various purlins are connected among themselves by rafters, which support a series of small secondary purlins upon which rests the glazing.

In the Liberal Arts Gallery, the glazing only extends as far as the fourth principal; in the Fine Arts Hall, where the presence of pictures and sculpture demands more light, the glazing is continued to the sixth frame. The side galleries, which lie alongside the nave, are constructed with a succession of principals of 15 meters (49 ft.) span, spaced 9·05 meters (27 ft. 7 in.) apart. These principals are fixed on one side by means of corbels on the upright part of the 50 meter principals, and at the other end upon square piers, measuring 0·6 meter by 0·8 meter (2 ft. by 2 ft. 8 in.), which rise to the gutters. These pillars, which form the exterior framework of the building, are united at their upper parts by trellised arches. At a height of 7 meters (23 ft.) above the ground, the lateral galleries are divided into separate stories by a wood floor, the beams of which are supported at the middle of the length by an iron pillar of U section. These beams are carried at one end on a wall which separates the grand nave from the lateral galleries, and on the other end they rest on lattice girders which stretch from pier to pier. At a distance of 1·25 meters (4 ft. 1 in.) from the center of the piers of the facade, and supporting the lattice girders, there is a series of small columns which form part of the scheme of decoration.

In the Hall of the Liberal Arts the flooring of the side galleries projects over the grand nave. It is car-

ried by corbels projecting 3·5 meters (11 ft. 6 in.) from the piers of the 50 meter principals. The principals of the side galleries have been designed with tie rods, an arrangement which effects considerable economy in their weight. Two-thirds of the widths of the galleries are glazed, and the principals are united by a system of seven purlins, of which five support the lantern.—*Industries.*

THE PHONOPORE.

WE now describe the system of telegraphy devised by Mr. Langdon-Davies, and which is based upon the employment of the special apparatus which he calls the "phonopore."

The phonopore consists essentially of an induction coil, having one primary and two secondary wires In circuit with the primary is the battery, transmitting apparatus (Morse key or otherwise), and a vibrating reed.

One of the two secondary coils has one end put to earth, while the other is insulated. The other secondary coil has its opposite end insulated, the wire then going to line. The apparatus is, therefore, equivalent to a condenser with self-induction; there is, moreover, no conductive circuit at all between the transmitting instrument at the home end and the receiving instrument at the distant end of the line.

The manner in which the phonopore can be made to work side by side with the ordinary telegraphs without in any way interfering with them, or being interfered with by them, will now be shown by describing in detail the actual phonopore line between St. Pancras and Leicester, and two or three of the numerous arrangements of phonoporic apparatus which Mr. Langdon-Davies has carried out in his laboratory.

The line upon which the recent demonstration was made is an ordinary telegraph line, 130 miles long, connecting London and Derby (Fig. 1).

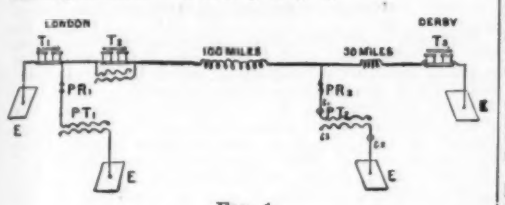


FIG. 1.

T_1 T_2 T_3 = Morse instruments. P R_1, P R_2 = phonopore receivers. P T_1, P T_2 = phonopore transmitters.

At the London end of the wire there are two telegraph stations, T_1 T_2, about half a mile apart, and at Derby there is a third telegraph station, T_3, all working ordinary Morse instruments through ordinary relays in the ordinary way.

At the London end of the line the phonopore is installed in deviation on the line ten yards from the terminal station, T_1, the distant phonopore being also in deviation at a point about 30 miles from T_3. One end of the phonopore line is therefore in close proximity to two ordinary telegraph stations less than a mile apart, while the distant post is on a branch line taken from a point in the main line where there is no other instrument.

Under these conditions the phonopore works absolutely independently of the ordinary service. In Fig. 2 we see the details of the phonopore station. The

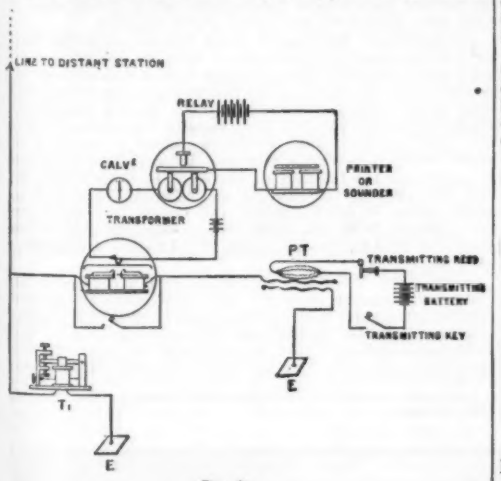


FIG. 2.

transmitting circuit, P T, consists of a Morse key, a battery of 30 cells, a vibrating reed, and the primary wire of the induction coil.

The reed is set in vibration on the depression of the key by an electro-magnet (also included in the circuit), and effects a rapid succession of makes and breaks in the primary circuit. In this way the manipulation of the key sends to line through the secondary coil a succession of rapidly alternating current waves in unison with the vibration of the reed.

One wire of the secondary goes to earth and the other is connected through the "transformer" to line. This transformer will presently be described in detail. A key is arranged to cut out the transformer when transmitting messages; if, however, the instrument is required to work duplex, the transformer line coils are wound differentially, and this cut-out is not used. So much for the transmitting apparatus.

In Fig. 3 we have a more detailed representation of the receiving apparatus, called by Mr. Davies the "transformer," which is in reality a delicate relay designed to enable the "phonoporic" current waves to work an ordinary Morse printer, or sounder.

Upon the soft iron core, I, are wound two coils, L C and A C; the coil, L C, is placed in the line wire of the secondary coils; the coil, A C, called the "augmenter," is in a local circuit in which there is a permanent current from a battery.

This local circuit includes, in addition to the battery and augmenter coil, a relay, a galvanometer, and the two vibrators, P V and T V, called respectively the "pendulum" and the "tongue." Over the iron core is placed a steel reed or diaphragm, R R, which, in harmonic telegraphy, is tuned to the rate of the dis-

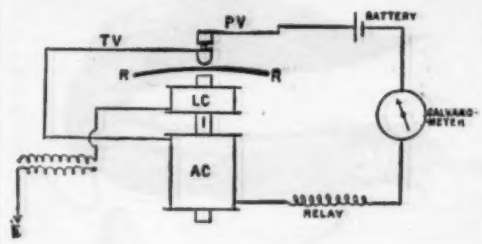


FIG. 3.

tant transmitter intended to work it. When the transformer is at rest the vibrator contacts are closed, and the current from the battery magnetizes the core and holds the reed in a state of tension.

In this condition it is important to notice that the reed is not touching the tongue. The action of the apparatus will now be easily understood. When intermittent currents reach L C from line, they act upon the reed, R R.

If, however, these vibrations consist of the comparatively slow and irregular impulses usual to ordinary telegraph work, or even of impulses of a regular and rapid character, but not accordant with the pitch of the reed, the vibrations of R R never acquire such an amplitude as to permit it to touch the tongue, and the contact between P V and T V is not, therefore, disturbed.

On the other hand, when impulses are given to R R at a rate corresponding to its natural time of vibration, it speedily acquires such an amplitude as to cause it to touch the tongue and disturb the contact of the vibrators.

This disturbance, increasing the resistance of the local circuit, reduces the strength of the current in the augmenter coil, A C, and the effect is then to release the reed, R R, from its condition of tension, and to cause it to strike smartly the tongue, T V, knocking away the pendulum, D V, and so long as the impulses continue to arrive in L C, the pendulum is unable to make an efficient contact with the tongue.

Now the current which magnetizes the core, I, also holds up the armature of the local relay, so that when the pendulum fails to make good contact with the tongue the armature of the relay falls and the printer, sounder, or other telegraph instrument in the relay circuit, is operated.

In some cases the relay may be dispensed with altogether, and the signaling instrument is then put in circuit with the augmenter coil in the position occupied by the relay. The resistance of the London and Leicester line is, we may add, about 4,000 ohms.

Returning for a moment to Fig. 1, we would call attention to a somewhat curious result obtained by Dr. Hopkinson and Prof. Silvanus Thompson. Treating P T_3 as a condenser, Dr. Hopkinson measured its capacity between t_1 and t_3, and made it 0·5 microfarad, the iron core of the coil being in. Measuring its capacity between t_1 and t_3 without the iron core, Prof. Silvanus Thompson arrived at the value 0·083 microfarad.

The extreme brevity of the duration of a "phonoporic impulse" suggested a doubt whether duplex receivers could be constructed so as to be practically useful. Experiment has, however, proved that there is no difficulty in working duplex receivers with ordinary differential coils, as shown in Fig. 4.

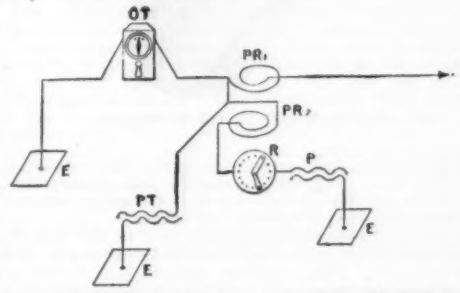


FIG. 4.—DUPLEX PHONOPORE TELEGRAPH WITH ORDINARY NEEDLE TELEGRAPH.

O T, ordinary telegraph; P R_1, P R_2, differential coils of the phonopore receiver; P T, phonopore transmitter; R, rheostat; P, simple phonopore.

At the recent demonstration, although it was not necessary to do so, one of the strands, P R_1, of the differential coil was placed in the line itself, the other, P R_2, in a balance line to earth, but not direct, a phonopore, P, being interposed between the rheostat and earth.

It is one of the many problems suggested by this apparatus that, inasmuch as the resistance of P is infinite, there should be no necessity to add any further resistance in R. The fact, however, remains that unless this resistance is so interposed, a balance cannot be obtained.

But, at the same time, this system of duplexing with the phonopore has an advantage over the ordinary system, since an exact balance is not required. At the demonstration at which we were present the resistance of the line was altered from 4,000 ohms to 14,000 ohms without disturbing the balance.

The balance, however, broke down when the resistance was raised to 23,000 ohms. At the same time, although the ordinary telegraph needle instruments could not be worked with their batteries of 20 cells each, the phonopores, with their batteries of 15 cells each, worked precisely as before.

Another system of duplexing a line is indicated in Fig. 5, where we have an ordinary telegraph line and instruments. If, now, a pair of simplex phonopores is

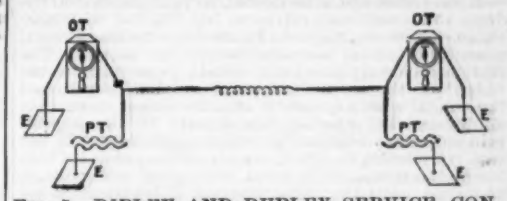


FIG. 5.—DIPLEX AND DUPLEX SERVICE, CONSISTING OF A SIMPLEX ORDINARY TELEGRAPH AND A SIMPLEX PHONOPORE TELEGRAPH

installed upon it, two services can at once be worked upon the single wire. The services being absolutely independent of each other, the line might, therefore, be worked either duplex or diplex, as required.

In Fig. 6 yet another method of duplexing is shown. In this case there is no balance line at all to regulate, but the duplexing of the instrument depends upon the tuning of the transmitting reeds in the transmitters, and the vibrators in the receivers.

P T_1 at A is a transmitter having a transmitting reed whose rate is the same as that of the receiver P R_2 at B. P T_2 at B is a transmitter, the rate of whose transmitting reed is the same as the rate of the receiver P R_1 at A.

The rates of these transmitting reeds are so calculated that they not only agree with those of their respective receivers, but so that they do not interfere with their home receiver. Thus, when the transmitter at A is worked, although its impulses pass directly through the receiver at A, they do not affect it, but they work the receiver at B, and *vice versa.*

The line shown in Fig. 6 is an ordinary "phonopore"

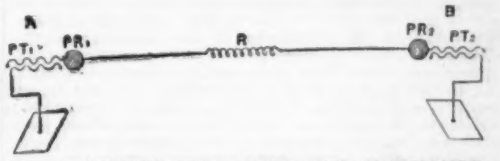


FIG. 6.—PHONOPORIC LINE, FOR HARMONIC DUPLEX WORKING.

line, terminating at both ends "in air." No ordinary telegraph can, therefore, be worked upon it. The battery power employed consists of 15 cells at each end, and the resistance of the wire is 100,000 ohms.

In Fig. 7 we have a perspective view of a simplex phonopore sounder. The transmitting and receiving organs are comprised in a single instrument, and they are intended to work simultaneously with ordinary telegraphs on lines up to 200 miles long. On a simple "phonoporic" line the sounder will work to a much

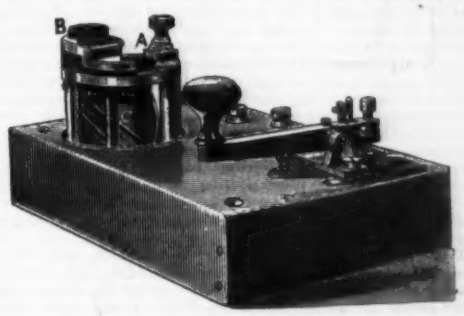


FIG. 7.—SIMPLEX PHONOPORE SOUNDER.

A = reed; B = contact screw; C = ends of secondary coils.

greater distance, the full extent of which has not yet been ascertained. It has worked well through a test line of 100,000 ohms.

We have described above only some half a dozen out of nearly forty combinations and adaptations of which the phonopore is at present capable, but we think we have said enough to make plain the general principle and the chief details of this beautiful instrument. In conclusion we may mention that Mr. Langdon-Davies is at present constructing two Wheatstone automatic instruments adapted to the phonopore.

These apparatus were not commenced until experiments had been made with two ordinary Wheatstone automatic instruments transmitting in place of the key of the phonopore transmitter. Although driven at the highest possible speed, the phonopore showed itself perfectly competent to deal with the signals.—*The Electrician.*

WASHING OUT THE ORGANISM IN CASES OF POISONING.

By Professor C. SANGUIRICO.

IT is well known that (1) all noxious or innocent bodies taken up by the organism are eliminated through the kidneys; (2) that the vascular system possesses the quality of becoming expanded by fluids injected in a quantity of about eight per cent. of the total weight of the organism, though neither local nor general changes are observed; (3) such an injection of indifferent fluids produces a considerable increase of vascular pressure, which ceases immediately when the elimination of the superfluous fluid injected into the circulation begins, which takes place through the natural channels, especially through the kidneys.

Relying on these physiologico-pathological principles, I tried to find out by experiments whether fatally poisoned animals may be saved from perishing when a rapid elimination of the poison is produced by thus increasing the secretion of the kidneys. Favorable results were obtained with alcohol, strychnine, chloral hydrate and aconitinum nitricum, but it failed with morphine, curarin and hypnon. I looked first for the minimal quantity of poison necessary to kill the animal. The fatal doses mostly stand in a certain proportion to the weight of the animal (rabbit, dog). I then poisoned the animal with a quantity slightly larger than that minimum, and injected immediately in the jugular vein a normal solution of sodium chloride (0·75 per cent.) in relation to eight per cent. of the animal, where the poison acts rapidly, as in strychnine or aconitine, or waited until the first symptoms of intoxication appeared (alcohol, chloral), when the injection was made. The results were always the same. After a shorter or longer interval copious micturition set in and the animals were saved. With the aconitinum nitricum copious micturition did not always set in, then the symptoms of poisoning kept on and the animals perished, or they recovered as soon as the scanty operation became copious. In examining the urine of the animals which were experimented upon, the poison used could always be detected. Perfect anuria was the result when the poison used was curarin, morphine, and hypnon, even then when the quantity injected amounted to ten per cent. of the weight of the animal. Professor Sanguirico intends to continue these interesting experiments on animals, particularly as it might be possible to save thus also a human life.—*Centralbl. der Med. Wissenschaften.*

THE EAST AFRICAN MUD FISH.

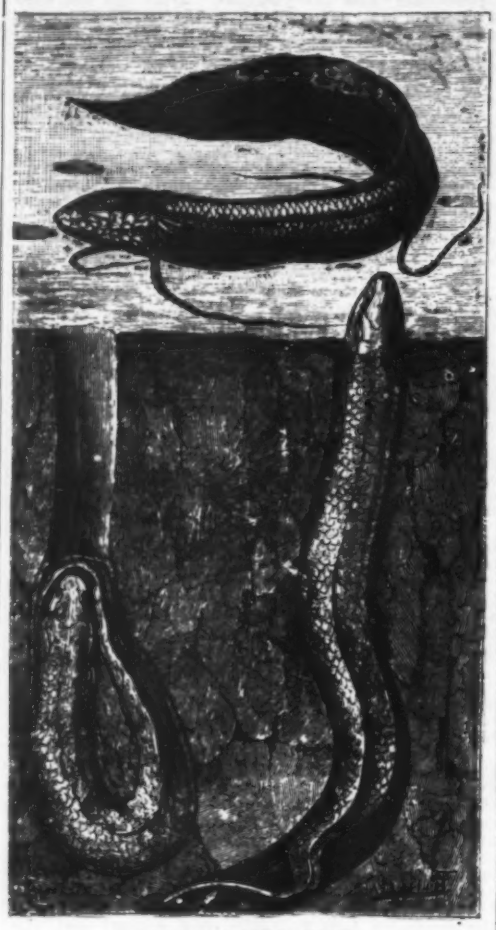
(*Protopterus annectens Ow.*)

THE managerie of the Natural History Museum in Paris has lately received a consignment of several specimens of this highly interesting fish, which is native to many of the rivers of tropical Africa, and is specially remarkable because of its close relationship—through its anatomical structure and its habits of life—to the amphibia.

At present there are only three species of this fish in existence The *protopterus* in question is found only in the rivers and morasses of Africa; the *Lediposiren paradoxa* lives in the tributaries of the Amazon; and the *Ceratodus Forsteri*, discovered in 1870 by Gerard Krefft, comes exclusively from the swamps of South Australia. These three species may be considered the last representatives of a group which was formerly widespread; otherwise it would be impossible to understand how each of the three continents should have its own peculiar lepidosiren, for the circumstance is explicable only by the theory that in the earlier geological periods these creatures were spread over the whole earth, and that the intermediate forms have died out, leaving only the few scattered species now known. From a scientific point of view these peculiar animals are specially interesting because of the possibility of classing them with equal correctness under the heads of "amphibia" and "fish," according to the accepted understanding of these terms, between which classes of vertebrates they form a veritable link. They are now classed among the fish by most zoologists, and in general appearance are very fish-like, the skin being covered with large scales, and the head not separated from the body. The construction of the brain, the digestive organs, and the reproductive organs is also similar to that of certain cartilaginous fishes. These discoveries justified the zoologists in their decision to place the problematic creatures with the fishes; but, nevertheless, it cannot be denied that on account of their double breathing (through the saculated lungs and the gills) and double heart chambers they might be classed with the amphibia. The lungs of the double breather are very primitive, consisting of two sacs lying outside of the abdominal cavity and opening by means of a common passage into the mouth, but acting as lungs, inasmuch as they take venous blood into the network of veins, and allow the arterial blood to go back to the heart.

The *protopteri* shown in our illustration are only moderately large animals, being from fifteen to twenty inches long, but specimens have been found which were twice as long. Those in Paris came from the Gambia river; they are found, however, all the way from Senegal to Mozambique. They are most abundant in the flooded swamps which are formed by the overflow of the rivers during the rainy season. Here they feed for the most part on water insects, little crabs and mud worms, but they sometimes attack larger prey, biting pieces from the fleshy parts of their bodies. They glide through the water in an eel-like manner, propelling themselves by means of their long, fin-like tails.

When the moisture of the swamps gradually evaporates and the heat begins to dry the earth, the *protopterus* ceases to breathe with its gills and makes use of its lungs. From an inhabitant of the water, it becomes an inhabitant of the land. According to the



AFRICAN MUD FISH.

(*Protopterus annectens Ow.*)

latest authorities, this change takes place in the following manner. As soon as the *protopterus* discovers that the level of the water is sinking, it makes a hole—large enough to contain its body—in the soft mud, enters this new dwelling place, and doubles itself up as shown in the accompanying cut. As soon as it has taken this position a slimy secretion covers its whole body, which,

COCOON OF PROTOPTERUS.

in a short time, hardens so as to form a shell or cocoon, in which it can wait undisturbed for the return of better days. During all this time it breathes by means of its lung sacs, the gills resting completely.

If one of these cocoons should be dug out of a dry swamp, it would look like the accompanying cut. The half-open cover shows us how the creature can escape from its voluntary captivity when it wishes to become an aquatic animal again. They can live in their cocoons from four to five months, and men take advantage of this power when they wish to send them long distances for scientific purposes. The specimens which are now alive in Paris had not only the five weeks' journey from MacCarthy's Island to Marseilles and from there to Paris, but they were for six months in a store house on MacCarthy's Island.

In order to free the *protopterus* from its cocoon it is only necessary to put it into water, and leave it there from twelve to fifteen hours, at the end of which the sac-like casing is softened enough to allow its occupant to slip out. As soon as it is free it swims about in the water, perfectly contented, and no one would imagine that it had been so long out of its element.

It is not known whether the *lepidosiren* and *ceratodus* can protect themselves in the same way as the *protopterus* from the dry season. The former (the South American mud fish) resembles the African one externally and also in some details of its internal structure so closely that it would seem safe to assume that it has this power; but the *lepidosiren* is so seldom seen that it will be a long time before there is any proof of its being able to make a cocoon. As to the *ceratodus*, it is so much more like ordinary fish than its two cousins that it is scarcely probable that it can protect itself in this way.

However, we ought soon to have certain knowledge in regard to this point, for the *ceratodi* swarm in the swamps of South Australia, and if the naturalists of that country would turn their attention to the subject they could give us the desired information.—*Illustrirte Zeitung.*

[Continued from SUPPLEMENT, No. 697, page 11142.]

HOW RAIN IS FORMED.*

By H. F. BLANFORD, F.R.S.

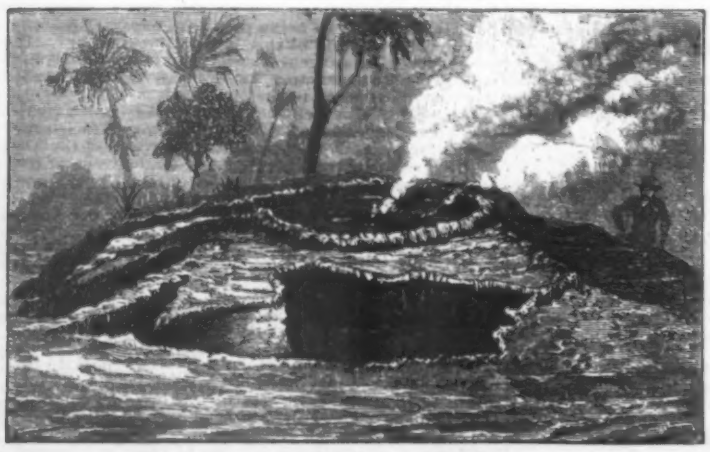
NOW let us see how these facts explain the formation of cloud; and first I will take the case of the common cumulus or heap-cloud, which is the commonest cloud of the day time in fine weather.

When, after sunrise, the air begins to be warmed, the lowest stratum of the atmosphere, which rests immediately on the ground, is warmed more rapidly than the higher strata. This is because the greater part of the sun's heat passes freely through a clear atmosphere without warming it, and is absorbed by the ground, which gives it out again to the air immediately in contact with it. So soon as the vertical decrease of temperature exceeds 1° in 183 feet, the warm air below begins to ascend, and the cooler air above to descend, and this interchange gradually extends higher and higher, the ascending air being gradually cooled by expansion, and ceasing to rise when it has fallen to the same temperature as the air around it. This ascending air is more highly charged with vapor than that which descends to replace it, since, as was mentioned before, most land surfaces furnish a large amount of moisture, which evaporates when they are heated by the sun. This process goes on until some portion of the ascending air has become cooled to the point of condensation. No sooner does it attain this, than a small tuft of cumulus cloud appears on the top of the ascending current, and the movement which was invisible before now becomes visible. In a calm atmosphere each tuft of cloud has a flat base, which marks the height at which condensation begins, but it is really only the top of an ascending column of air. No sooner is this cloud formed than the ascent becomes more rapid, because the cooling which checked its further ascent now takes place at a much slower rate, and, therefore, the cloud grows rapidly.

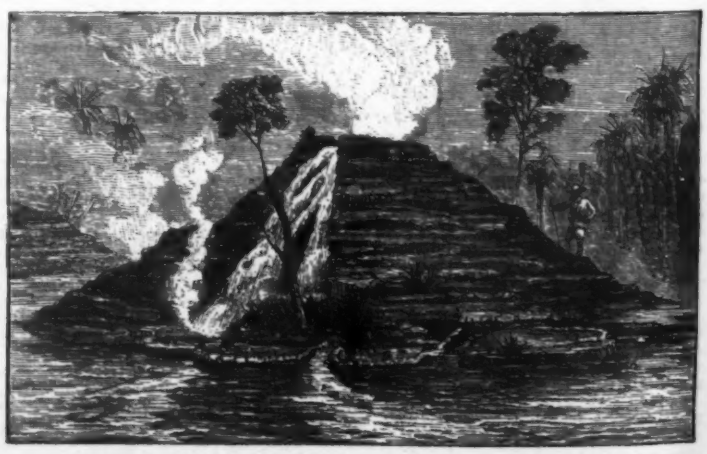
On a summer afternoon, when the air is warm and very damp, such cumulus cloud ascends sometimes to very great heights, and develops into a thunder cloud, condensing into rain. Rain differs from fog and cloud only in the size of the water drops. In fog and cloud these are so minute that they remain suspended in the air. But, as the cloud becomes denser, a number of them coalesce to form a raindrop, which is large enough to overcome the friction of the air. It then begins to fall, and, having to traverse an enormous thickness of cloud below, it grows larger and larger by taking up more and more of the cloud corpuscules, so that when finally it falls below the cloud, it may have a considerable size.

Such, then, is the mode in which rain is formed in an ordinary summer shower; and the more prolonged rainfall of stormy wet weather is the result of a similar process, viz., the ascent and dynamic cooling of the moist atmosphere. But in this case the movement is on a far larger scale, being shared by the whole mass

* A lecture delivered at the Hythe School of Musketry on November 19, 1888.—*Nature.*



THE HAROLD SPRING, EINSLEIGH RIVER.



THE COOK SPRING, EINSLEIGH RIVER.

HOT SPRINGS IN NORTH QUEENSLAND, AUSTRALIA—SKETCHES BY THE EXPLORER A. J. VOGAN.

of the atmosphere, it may be, over hundreds or thousands of square miles; and to understand this movement we shall have to travel somewhat further afield, and to inquire into the general circulation of the great atmospheric currents set in movement by the sun's action in the tropics, and modified by the earth's diurnal rotation and the distribution of the continents and oceans on its surface.

Before, however, entering on this subject, which will require some preliminary explanation, and in which we shall have to take account both of ascending and descending currents on a large scale, I will draw your attention to another and simpler case, in which both these classes of movements are prominently illustrated, and in which they exhibit their characteristic features in a very striking manner.

In the valleys of the Alps, more especially those to the north of the central chain, in Switzerland and the Tyrol, there blows from time to time a strong warm dry wind, known as the Fohn. It blows down the valleys from the central chain, melting the snows on its northern face, and although there is more or less clear sky overhead, all the southern slopes of the mountains are thickly clouded, and heavy rain falls on the lower spurs and the adjacent plain, replaced by snow at the higher levels up to the passes and the crest of the range. Cloudy weather also prevails to the north in Germany, and the weather is stormy over some part of Western Europe.

It is only since the general introduction of telegraphic weather reports and the construction of daily weather charts have enabled us to take a general survey of the simultaneous movements of the atmosphere over the greater portion of Europe, that this Fohn wind has been satisfactorily explained.* It is found that when a Fohn wind blows on the north of the Alps, the barometer is low somewhere to the north or northwest, in Germany, Northern France, or the British Isles, and high to the southeast, in the direction of Greece and the Eastern Mediterranean. Under these circumstances, since the winds always blow from a place of high barometer to one of low barometer, a stong southerly wind blows across the Alps.

On their southern face it is forced to ascend, and therefore, as just explained, it is cooled and gives rain in Lombardy and Venetia, and snow at higher elevations. But having reached the crest of the mountains, it descends to the northern valleys, and being by this time deprived of a large part of its vapor, it becomes warmed in its descent, owing to compression, absorbs and re-evaporates the cloud carried with it, and is then further warmed at the rate of 1° for every 183 feet of descent. Thus it reaches the lower levels as a warm, dry wind, its warmth being the effect of dynamic heating.

Other mountain chains afford examples of the same phenomenon. A very striking instance, which much impressed me at the time, is one that I witnessed many years ago in the mountains of Ceylon; and it was afterward mentioned to me by Sir Samuel Baker, who had been equally struck by it. My own experience is as follows: In June, 1861, I paid a week's visit to the hill sanitarium of Newara Eliya, at an elevation of 6,200 feet, on the western face of Pedro Talle Galle, the highest mountain in the island.

The southwest monsoon was blowing steadily on this face of the range; and during the whole time of my stay it rained, as far as I am aware, without an hour's intermission, and a dense canopy of cloud enveloped the hill face, and never lifted more than a few hundred feet above the little valley in which Newara Eliya is built. But on leaving the station by the eastern road that leads across the crest of the range to Badulla, at a distance of five miles one reaches the *col* or dip in the ridge near Hackgalle, and thence the road descends some 2,000 feet to a lower table land which stretches away many miles to the east. No sooner is this point passed than all rain ceases and cloud disappears, and one looks down on the rolling grassy hills bathed in the sunshine of a tropical sun, and swept by the dry westerly wind that descends from the mountain ridge. In little more than a mile one passes from day-long and week-long cloud and rain to constant sunshine and a cloudless sky.

As an almost invariable rule, or at least one with few exceptions, ascending air currents are those that form cloud and rain, and descending currents are dry and bring fine weather. And this holds good whatever may be the immediate cause of these movements. We may now proceed to consider these greater examples to which I have already referred.

In the great workshop of nature, in so far at least as concerns our earth, with but few exceptions, all movement and all change, even the movements and energies of living things, proceed either directly or indirectly from the action of the sun. Nowhere is this action more direct and more strikingly manifested than in the movements of the atmosphere. Were the sun extinguished, and to become, as perhaps it may become long ages hence, a solid, cold sphere, such as Byron imagined, "wandering darkling in eternal space," a few days would suffice to convert our mobile and ever-varying atmosphere into a stagnant pall, devoid of vapor, resting quiescent on a lifeless earth, held bound in a more than Arctic frost. From such a consummation, despite the supposed decaying energy of our sun, we may, however, entertain a reasonable hope that we are yet far distant.

Bearing in mind the all-embracing importance of the sun, let us see how the great movements of the atmosphere are determined by the way in which the earth presents itself to the solar rays.

Since the quantity of solar heat received on each part of the earth's surface depends on the directness or obliquity of his rays—in other words, on the height to which the sun ascends in the heavens at noon—being greatest where he is directly overhead, as in summer in the tropics, it follows that the hottest zone of the earth is that in the immediate neighborhood of the equator, and the coldest those around the poles.

Did time allow, and were the necessary appliances at hand, it would be easy to show you that both as a matter of experiment, and also as a deduction from physical laws, there must be under such circumstances a flow of air from the colder to the warmer region in the lower atmosphere, and a return current above. And to a certain extent we have these constant winds prevailing for about 30° on either side of the equator, in the trade winds, which blow toward the equator in the lower atmosphere, and the anti-trades blowing in the opposite direction at a great height above the earth's surface.

In the neighborhood of the equator there is a zone extending right round the earth in which the barometer is lower than either to the north or the south. It is due to the greater heat of the sun, and it is toward this that the trade winds blow. It shifts to some extent with the seasons, being more northerly in the summer of the northern hemisphere, and more southerly in that of the southern hemisphere; and its average position is rather to the north of the equator, owing to the fact that there is more land in the northern than in the southern hemisphere, and that land is more heated by the sun than the ocean.

This simple wind system of the trades and anti-trades does not extend right round the earth, nor beyond 30° or 40° of latitude in either hemisphere. Were the earth's surface uniformly land or uniformly water, there probably would be a system of trade winds all round the globe, blowing from both hemispheres toward the equator; but even in that case they would not extend much, if at all, beyond their present limits. In the first place, every great mass of land sets up an independent system of air currents, since the land is hotter than the ocean in the summer, and colder in the winter. In the summer, therefore, there is a tendency to an indraught of air from the sea to the land in the lower atmosphere, and an outflow above, and in the winter the opposite; and this tendency modifies or interrupts the system of the trades and anti-trades. We have this tendency shown most distinctly in the monsoons of Southeastern Asia, where, both in the India and China seas, a southwest wind in the summer takes the place which in the absence of the Asiatic continent would be held by a northeast trade wind. And it is only in the winter that a northeast wind blows, and this is then termed the northeast monsoon.

In the second place, as I have said, the system of trade winds could not in any case extend far beyond their present limits in latitude, owing to the fact that the earth is a sphere and not a cylinder. Let us fix our attention for a moment on the anti-trades—the upper winds which blow from the equator toward the poles. The equator, from which they start, is a circle about 24,900 miles in circumference; the poles are mere points, and, therefore, the whole of the air that blows toward the poles must turn back in any case before it reaches the pole, and must begin to turn back before it has gone very far on its journey. And, as a fact, a great part of it does turn back between 30° and 40° of latitude, which I have already mentioned as being the limit of the trade winds. A part of the remainder descends to the earth's surface, and sweeps the Northern Atlantic and the North Pacific as a southwest wind.

On the chart which represents the average distribution of atmospheric pressure in January, there are two somewhat interrupted zones of high pressure over the ocean in these latitudes. These mark the regions in which the anti-trades descend to the earth's surface, and from which the trade winds start. Over the ocean in all higher latitudes, both in the northern and southern hemispheres, the barometer is low—for the most part, indeed, much lower than over the equator; and the region intervening between the zones of high pressure and the seat of lowest pressure is that of predominant southwest, or at all events westerly, winds. Since our islands are situated on the border of this region of low pressure, southwest are our prevailing winds.

But now two questions arise: first, Why are these winds westerly, and not simply south winds? and second, How is it that the barometer is so low over the North Atlantic and North Pacific Oceans, and also in the southern hemisphere in high latitudes, seeing that in these latitudes, at least in winter, the sun's heat is so much less than at the tropics? The chart represents the state of things in midwinter of the northern hemisphere, and yet everywhere to the north of latitude 40° the deep blue tint indicates that the pressure is lower than even in the southern tropic, where the sun shines vertically overhead. Clearly this low pressure must be due to some other cause than the warmth of the air.

The explanation of this remarkable distribution of the atmospheric pressure, of the existence of two zones of high pressure in latitudes 30° to 40°, and of very low pressure in higher latitudes, except in so far as they are modified by the alternations of land and water, was first given by the American physicist, Prof. Ferrel. Its full demonstration is to be obtained only from the consideration of somewhat recondite mechanical laws, but a general idea of the causes operating may be gathered from very simple considerations, which may be demonstrated with a terrestrial globe.

Starting with the well-known fact that the earth revolves on its axis once in the twenty-four hours, let us see what will be the consequence, if we suppose a mass of any ponderable matter—that is, any substance having weight, no matter whether light or heavy—to be suddenly transferred from the equator to latitude 60°.

As the circumference of the earth at the equator is about 24,900 miles, any body whatever, apparently at rest at the equator, is carried round the earth's axis at the rate of 1,036 miles an hour. But in latitude 60°, where the distance from the axis is only half as great as at the equator, it is carried round at only half the same rate, or 518 miles an hour; and at the pole it simply turns round on its own axis.

Supposing, then, a mass of air to be suddenly transferred from the equator to latitude 60°, with the eastward movement that it had at the equator, it would be moving twice as fast to the east as that part of the earth, and, to any person standing on the earth, would be blowing from the west with a force far exceeding that of a hurricane. It would be moving eastward 518 miles an hour faster than the earth. Indeed, its movement would really be far greater than this. In virtue of a mechanical principle known as the law of the conservation of areas, which means that any body revolving round a central point, under the influence of a force that pulls it toward that point, describes equal areas in equal times, instead of only 518 miles, it would be revolving round the earth's axis 1,554 miles an hour faster than that part of the earth. I need not, however, specially insist on this point, because, as a matter of fact, the air which constitutes the anti-trades is not suddenly transferred, but takes a day or two to perform its journey, and in the meantime by far the greater part of its eastward movement is lost by friction against the trade wind which blows in the opposite direction underneath it.

The point on which we have to fix our attention is that, when the anti-trades descend to earth, they still retain some of this eastward movement, and blow, not as south, but as southwest or west-southwest winds.

On the other hand, the trade wind, which blows toward the equator, is coming from a latitude where the eastward movement is less than at the equator, and its own movement eastward is therefore less than that of the surface over which it blows. A person, therefore, standing on the earth is carried eastward faster than the air is moving, and the wind seems to blow against him from the northeast. Similarly, to the south of the equator, the trade wind, instead of blowing from the south, comes from the southeast.

Thus, then, we have in both hemispheres a system of westerly winds in all higher latitudes than 40°, and a system of easterly winds—viz., the trade winds—between about 30° and the equator; and if the globe were either all land or all water, these systems would prevail right round the earth.

Now, it is the pressure of these winds, under the influence of centrifugal force, that causes the two zones of high barometer in latitudes 30° to 40°, and the very low pressure in higher latitudes. It is not difficult to understand how this comes about. You are probably aware that the earth is not an exact sphere, but what is termed an oblate spheroid—that is, it is slightly flattened at the poles and protuberant at the equator, the difference of the equatorial and polar diameters being about 26 miles. It has acquired this form in virtue of its rotation on its axis.

If you whirl a stone in a sling, the stone has a tendency to fly off at a tangent, and, so long as it is retained in the sling, that tendency is resisted by the tension of the cord. In the same way, every object resting on the earth, and the substance of the earth itself, has a tendency to fly off at a tangent, in consequence of its rotation on its axis, and this tendency is resisted and overcome by gravity.

Were the earth not revolving, its form, under the influence of gravity alone, would be a true sphere. If it were to revolve more rapidly than at present, it would be still more oblate, flatter at the poles and more bulging in the tropical zone; if less rapidly, the flattening and bulging would be less.

This is precisely what happens with the west and east winds of which we have spoken. West winds are revolving faster than the earth, and tend to make the atmosphere more protuberant at the equator than the solid earth; hence they press toward the equator, to the right of their path in the northern hemisphere, and this tendency increases rapidly in high latitudes. Easterly winds, on the other hand, tend to render the form of the atmosphere more nearly spherical, and they, too, press to the right of their path in the northern hemisphere or toward the pole. In the southern hemisphere, for the same reason, both press to the left. The result of these two pressures in opposite directions is to produce the two zones of high barometer in the latitudes in which we find them, viz., between the easterly trade winds and the westerly winds, which are the anti-trades that have descended to the earth's surface. And the low barometer of higher latitudes is produced in like manner by the westerly winds pressing away from those rigions.

Thus, then, we find that all this system of winds, and the resulting distribution of atmospheric pressure as indicated by the barometer, is the result of the sun's action in equatorial regions. It is this that gives the motive power to the whole system, so far as we have as yet traced it, and it is this that produces those great inequalities of atmospheric pressure that I have so far described.

It remains now to see how storms are generated by these westerly winds. In so far as they retain any southing, they are still moving toward the pole in the northern hemisphere—that is to say, they are advancing from all sides toward a mere point. Some portion of them must therefore be continually turning back as the circles of latitude become smaller and smaller. But they are now surface winds, and in order so to return they must rise and flow back as an upper current. This they do by forming great eddies, or air whirls, in the center of which the barometer is very low, and over which the air ascends, and these great air whirls are the storms of the temperate zone and of our latitudes. It is the ascent and dynamic cooling of the air in these great eddies that cause the prolonged rainfall of wet, stormy weather. How the eddies originate, or, rather, what particular circumstance causes them to originate in one place rather than another, we can scarcely say, any more than we can say how each eddy originates in a rapidly flowing deep river. Some very small inequality of pressure probably starts them, but, when oneed formed, they often last for many days, and travel some thousands of miles over the earth's surface.

Two such storms are represented on the charts of February 1 and 2, 1883, one on the coast of Labrador, the other to the southwest of the British Isles. The first of these appears on the chart of January 28, in the North Pacific, off the coast of British Columbia. On the 29th it had crossed the Rocky Mountains, and was traversing the western part of the Hudson's Bay Territory. On the 30th it had moved to the southeast, and lay just to the west of the Great Lakes, and on the 31st between Lake Superior and Hudson's Bay. On February 1 it had reached the position on the coast of Labrador shown in the chart, and on the 2d had moved further to northeast, and lay across Davis' Straits, and over the west coast of Greenland. After this it again changed its course to southeast, and on February 4 passed to the north of Scotland, toward Denmark, and eventually on to Russia.

The second storm had originated off the east coast of the United States between January 28 and 29, and on the following days crossed the Atlantic on a course somewhat to north of east, till, on February 2, it lay over England.

These storms always move in some easterly direction, generally between east and northeast, and often several follow in rapid succession on nearly the same track. It is this knowledge that renders it possible for the Meteorological Office to issue the daily forecasts that we see in the newspapers. Were it possible to obtain telegraphic reports from a few stations out in the North Atlantic, these storm warnings could be issued

* The explanation was originally given by Prof. J. Hann, of Vienna.

with much more certainty, and perhaps longer before the arrival of the storm than at present. In the case of such storms as that which reached our islands on February 2, we often have such warnings from America, but their tracks are often more to the northeast, in the direction of Iceland, in which case they are not felt on our coasts, and hence the frequent failure of these American warnings.

It is the region of low pressure in the North Atlantic that is the especial field of these storms. As they pass across it they produce considerable modifications in the distribution of pressure, but some of its main features remain outstanding. Thus there is always a belt of high barometer between the storm region and the trade winds, and in the winter there is almost always a region of high barometer over North America, and another over Europe and Asia, however much they may shift their places, and be temporarily encroached on by the great storm eddies.

These regions of high pressure are the places where the winds descend, and, as I mentioned in the earlier part of this lecture, these winds are dry, and generally accompany fine weather. On the contrary, the eddies, where the air ascends, are damp and stormy, and especially that part of the eddy that is fed by the southwest winds that have swept the Atlantic since their descent, and so have become charged with vapor.

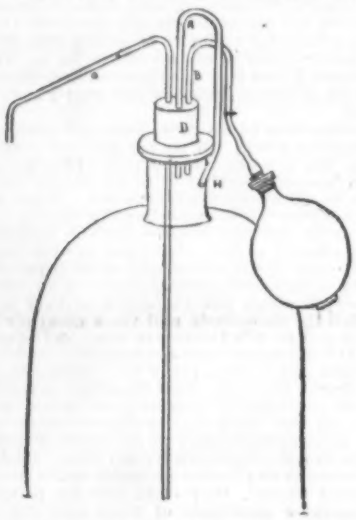
And now we are prepared to understand why east, and especially northeast, winds are generally so dry. They are air that has descended in the area of high barometer that, especially in the winter and spring, lies over Europe and Asia, and has subsequently swept the cold land surface, which does not furnish much vapor, and therefore they reach us as dry, cold winds. To begin with, the air comes from a considerable height in the atmosphere, and in ascending to that height in some other part of the world, it must have got rid of most of its vapor in the way that has been already explained. In descending to the earth's level it must, of course, have been dynamically heated by the compression it has undergone, but all or nearly all this heat has been got rid of by radiation into free space on the cold plains and under the clear frosty skies of Northern Asia and Northern Europe, and it then blows outward from this region of high barometer over the land, toward the warmer region of low barometer on the North Atlantic Ocean.

Thus we see that, in all cases, rain is produced by the cooling of the air, and that in nearly all, if not all, this cooling is produced by the expansion of the air in ascending from lower to higher levels in the atmosphere, by what is termed dynamic cooling. This last fact is not set forth so emphatically as it should be in some popular text books on the subject, but it is an undoubted fact. It was originally suggested by Espy some forty years ago, but the truth is only now generally recognized, and it is one of the results which we owe to the great advance in physical science effected by Joule's discovery of the definite relation of equivalence between heat and mechanical work.

A SIMPLE ACID PUMP.

ALTHOUGH this device, in slightly different forms, has been in use for some time, yet the convenience of the modification here figured may render it worthy of description.

A, B and C are three glass tubes passing through the rubber stopper, D, A and B ending just below the



stopper, and C reaching to the bottom of the bottle. To B is attached a double-valve rubber bulb. A is so bent that while the bulb is clasped in the hand, the thumb can easily be held over the open end of A at H. Acid can then be forced out through C, and the flow may be checked instantly by removing the thumb from H. The left hand is thus left free to hold under C the vessel into which the acid is to flow. A glazed earthenware dish is placed upon the table under C to catch the drippings.

For the use of large classes of beginners in general chemistry this apparatus is well adapted, since accidents resulting from careless handling are rendered almost impossible, and both acid and time are economized.

The same device may be used for carboys, the tube, C, being extended upward so that an acid bottle may stand on the box beneath it, and H being kept closed by a piece of rubber tubing and a pinch cock.—*L. M. Dennis in Amer. Chem. Jour.*

A VALUABLE BLUE REDISCOVERED.

PROFESSOR FOUQUE, of the College de France, at the last meeting of the Academy of Sciences (February 18) read an important memoir on the blue pigment used by the ancient Romans for wall decorations. It is a magnificent color, as bright to-day as when first applied, and is found in the fresco paintings of Pompeii and other monuments dating from the Roman period. Its production is one of the lost arts, as there is no record of the pigment being used after the invasion of the Barbarians. Modern chemists have more than once tried to ascertain the nature of the compound, but beyond the point that it contains copper nothing definite was discovered. M. Fouque thinks the lack of success is owing to the fact that the ancients followed no exact rules or proportions. Having secured comparatively copious specimens of the cœruleum—such is the old name of the pigment—he has succeeded not only in analyzing it, but also in finding a process for making it regularly in quantities. The compound is, according to M. Fouque, a quadruple silicate of copper and lime, which may be prepared with silica, oxide of copper, and lime, with or without any fluxes. The ancients simply made it with sand, calcined or roasted copper, and lime, but kept to no regular proportions. He worked differently, and managed to obtain an exact chemical combination, which is neither a glass nor an enamel, but a crystalline substance of the composition already mentioned.

The crystals are perfectly definite, and strongly dichroic, appearing deep sky blue when viewed from the surface, and pale rose edgeways. The only difficulty in the preparation is the heating. A bright red heat is necessary to effect the combination, but on heating too much, the blue color is lost and an aventurine green glass is obtained, a circumstance which must have rendered the process a delicate one in old times. Nowadays, however, with the means at our disposal, the difficulty is trifling, and kilogs. of the cœruleum could easily be made in the College de France laboratory. It is a very stable pigment, so far as chemicals are concerned, as it stands, unaffected, boiling with sulphuric acid or potash lye, as well as quicklime and hydrogen sulphide. That it will be air and water proof is abundantly shown by the old fresco paintings. M. Fouque considers, therefore, it would be a great boon to the arts to produce the blue commercially, and promised his assistance to any French manufacturer who will undertake the fabrication. While examining the fine specimens of the rediscovered blue presented by M. Fouque, M. Berthelot, who is well versed in ancient chemical lore, remarked the cœruleum in question was no doubt the Alexandria blue, known in Egypt about the beginning of the Christian era, and taken to Pozzuoli, whence its use spread all through Italy. He agreed with M. Fouque that the pigment was unknown to the Assyrians and ancient Egyptians, and is no doubt a most valuable one.—*Chemist and Druggist.*

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